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North Haven Collision Controversy as to the real cause has usually followed serious railroad wrecks. In the disaster on the New Haven this week, however, in which twenty-one persons were killed and fifty hurt, we have the engineer's word that fog prevented him from seeing a stop signal until too late to avoid collision. It is but another evidence of the lax management and poor discipline to which are attributable the long series of New Haven disasters. Individual accidents can be explained by specific causes, but underlying all are these fundamental disorders. It is not unlikely that the troubles of this one road may be the means of saddling upon the railroads in general enormous burdens for improved signaling and steel coaches. Legislators may refuse to consider that thousands of passengers daily ride in safety in wooden coaches under present signaling methods. They may not recognize that discipline is a greater safety device than elaborate signaling system or a non-collapsible coach. It may be that the courts would stop legislation of a confiscatory nature even though the laws were framed to insure greater safety. Undoubtedly the installation of better signaling and the substitution of steel for wooden cars are desirable. Both are being done on most roads as rapidly as the financial situation will allow. To force the roads into more rapid changes will likely aggravate the financial troubles with which they are afflicted.

Dangerous Bridge Floors Again In the Engineering Record of Aug. 23 attention was called to the fire hazard of wood floors in steel bridges. That the lesson taught by the Portland Bridge fire has not gone unheeded is demonstrated by the attitude of the chief of Tacoma's fire department in calling attention to the dangerous situation of the new City Waterway bridge. The municipal dock—a fire trap, he terms it—is beneath the structure. Should it take fire the flames would attack the creosote blocks, gain headway quickly and be difficult to stop. Evidently the danger has not been hitherto appreciated. No hydrants or engine attachments are on the bridge; the city has no fireboat, from which alone the main span could be reached by a fire stream; and the end of the dock, against the bridge, has practically no fire protection. In his opinion as to the danger the chief is supported by the superintendent of the city docks. The latter urges the shortening of the structure, while the fire chief recommends its removal, and, in addition, the purchase of a fireboat. Other officials should profit by this example, for undoubtedly there are exposed wooden bridges elsewhere.

"Pond-Week" Fallacy Comment was made in these columns last week on the dangers attendant upon "good-roads days" which are not accompanied by educational campaigns. In these "days," however, a certain well-defined task approved of by all is performed. When, however, the enthusiasm for the good-roads day idea is allowed to spread to untried and uncertain fields it is time to call a halt until competent counselors have spoken. The Governor of Kansas, spurred by the good-roads accomplishments of his doughty neighbor, the Governor of Missouri, now proposes, so press dispatches state, to have a "pond week"—not a mere pond day—in September, during which "he hopes to see 100,000 ponds, averaging at least an acre in area, built for the conservation of the coming winter's snow and rainfall." This is the Governor's solution for the drought which last month was a serious problem to the stock raisers and farmers of the state. Unquestionably the problem is an important one, but the way to solve it is not to rush into a pond-building week but to engage competent engineering advisers, who, after study of the rainfall and geologic factors, will report a proper remedy. The slogan, "Do it now!" needs amendment by adding, "But first be sure you're right!"

Life of Bond Issues Favorable comment has been made in these columns in the past on the regulation by English authorities of the periods for which bonds may be issued for the construction of various works. It has been fully recognized by them that the life of the bond should bear some relation to that of the structure on which it was issued. A Massachusetts law which becomes effective on Jan. 1, 1914, contains provisions based on this idea. For example, sewers, sewage-disposal and water-supply systems and parks are to be paid for in 30 years; public buildings, bridges and gas and electric-lighting plants in 20 years; streets and highways, and "stone, block, brick or other permanent pavement," 10 years; macadam pavement, 5 years; sidewalks of material of lasting character, 5 years. While it is customary in the United States to set periods for the repayment of debts, they are generally adopted arbitrarily. The most flagrant case is the 50-year-bond plan for pavements and highways, which, under the very best conditions and construction, do not last over 20 years or 25 years. The subject is one that engineering societies may well take up for the benefit of their respective communities.

Attitude of the Irrigationists Comments by papers in the Pacific Northwest on the progress of the Secretary of the Interior through the irrigated sections indicate a decided change in popular attitude. At the time the secretary took office there came down upon him a hurricane of protest with reference to the Reclamation Service which would have upset most men and resulted in a "shaking up" of that organization. Had that sentiment persisted, even though he himself had done nothing to incur criticism, the secretary would not have been received in the West with the cordiality he has experienced in his present trip. The wisdom of his policy of bringing the protestants to Washington, patiently listening to their story and requesting their assistance in solving the government's difficulties has been fully demonstrated. It required great mental and moral strength to hold one's own in that storm, but its passage has apparently left the secretary with a strong following throughout the irrigated sections. The conference apprised him of the great difficulties under which both public and private irrigation enterprises are laboring, while they convinced the settlers of his sympathetic and judicial attitude. The result has been a friendly spirit which, if continued, should aid materially while working out the tremendous problem of developing the national irrigation projects into "going concerns." The settlers now realize more keenly than ever the difficulties which must be met; if, going a step farther, they would accept them as economic and not as political problems, valuable time and energy would be saved. Appeals for relief to congressmen are not a satisfactory way of solving problems in irrigation management and development—especially when the Department of the Interior has the receptive attitude shown by its present head.

Standardizing Sewerage Plans The old problem of making bricks without straw has a counterpart in the task which confronts many state boards of health—that of passing upon plans for sewerage systems, treatment works, water supplies, and filtration plants that do not contain data upon which an intelligent estimate of their value can be based. In New Jersey, for instance, requests for the approval of plans sketched on pieces of wrapping paper are not without precedent. Sometimes it happens that engineers will prepare designs for sewage-treatment works without adequate investigation of local conditions or appreciation of the highly specialized knowledge required for successful design. The building of the plant according to these plans would certainly result in a menace to the community or a total loss of the investment. It devolves upon the health board to intervene and insist upon the correction of the design and the furnishing of full data. The board's force, however, must necessarily waste much time in correspondence relative to missing and inadequate data and plans if this lax procedure is allowed to continue. To lessen the delays, therefore, Mr. Fitz-Randolph, chief of New Jersey's division of water and sewerage, has evolved a set of rules and regulations governing the submission of designs for the board's approval. These, in so far as they relate to sewerage, are published on page 273. The waterworks rules will appear in an early issue. This set of regulations specifies exactly the board's requirements and should prove of great value. The pamphlet is not the work of a single individual; before its adoption it was submitted for criticism to a number of prominent sanitary engineers and from them many helpful suggestions were received. The rules, therefore, embody what is accepted as good practice in present-day design of sewerage systems and treatment works and as such should have a range of usefulness far beyond the limits of New Jersey.

Buying Small Pumps The use of motor-driven, centrifugal pumps for small waterworks is increasing, and there can be little question as to their suitability in many cases. The importance of high efficiency when using relatively expensive power is not always fully understood. Electric motors of good efficiency can usually be obtained, but considerable trouble is often experienced in obtaining a centrifugal pump having high efficiency under special conditions of head and discharge. The difference in the annual operating expenses of pumps at 60 per cent and at 70 per cent efficiency is about $1 per gallon rating (per minute) when operating

10 hours per day against a head of 100 ft., the motors having efficiencies of 85 per cent and power costing 5 cents per kilowatt hour. That is, the 60 per cent pump would cost $200 per year more to operate than the 70 per cent pump if the capacity were 200 gal. per minute. It is evident that the pump having 60 per cent efficiency is not worth as much as the other and that under some circumstances it would be poor economy to accept it as a gift. In a recent case two motor-driven, centrifugal pumps guaranteed at 70 per cent developed only 60 per cent when tested in place. The specifications under which the pumps were bought did not cover this contingency, and no satisfactory solution as to payment or acceptance has yet been reached. As is well known, the efficiency of a centrifugal pump is not the same for all discharges. When a pump is to operate through a wide range of discharge the specifications should exclude pumps having peaked efficiency curves. In any case they should be explicit as to the efficiency expected at several heads and discharges, and should state the lowest efficiency which will be considered. A deduction should be made from the bid price for every per cent the pump falls below the expected efficiency for the discharge at which the pump will usually operate, and a bonus should be given for exceeding it. To prevent disputes, the specifications should also include a definition of efficiency, while provision for testing under the supervision of a competent engineer representing the owner should be made. In purchasing large units proper attention is generally given these matters, but there is an unfortunate tendency to neglect these essentials when purchasing smaller units, though for the communities in question the transactions are equally important.

Federal Aid for Highways

In these days when the mulcting of the Federal government is looked upon as an indication of patriotism and the odium which formerly attached to the word "paternalism" has disappeared, one heaves a sigh of relief at the discovery of a newspaper which has the hardihood to stand up against the latest pork-barrel propaganda. Referring to the National Highway Association, whose propaganda was adversely criticised in this journal several weeks ago, the Charlotte (N. C.) "Observer" says: "Recently an official of the National Highways Association called on the 'Observer' and insisted upon having a written expression of its views on roadbuilding in connection with the plans of the National concern. The 'Observer' gave it to this effect: It favors the promotion of roadbuilding in this country through individual township, county, district and state effort as the speediest and most effective system of securing good roads, and that as the states build these roads they connect up with the proposed across-the-continent road, in effect thus creating this central road themselves. It would welcome and advocate Federal aid as auxiliary to these state efforts. In other words, self-help should be the reliance of the people in securing good roads. We should put the securing of government aid of secondary importance, rather than of first importance."

With this expression the Engineering Record is in hearty accord, though, theoretically, it does not favor national aid in highway construction. Roads are local, not national, problems. The appropriation of Federal funds is but a lazy man's scheme for shifting the burden and a play of the politicians for the rural vote.

Nevertheless, the propaganda has gone so far that there is little hope of stopping it. To continue to oppose Federal aid in some form is like butting one's head against a stone wall. Federal aid is inevitable, and all that can be done now is to guide it into sane channels. To this end the highway officials and engineers who refuse to be stampeded into the rabid Federal-aid camp would do well to work together. We have enough squandering of public funds—on useless public buildings, waterways and harbors—without adding to the absurdity by throwing 100,000 miles of highways into the pork barrel. Alongside this juicy tenderloin, public buildings and harbors would look like cheap cuts.

The Coming Road Congress

With the Third American Road Congress only three weeks off, the Engineering Record urges its readers—contractors, highway officials and engineers—to consider earnestly the varied program announced in last week's issue. The perfecting of the organization shows its fruits in the plans for the congress. The program covers every phase of the subject, and through the energy of the officers the dead framework of a plan has been vivified by the acceptance of program assignments by men of experience and recognized standing. While the entire program may not, at first sight, appeal to all, it is urged that the engineers do not come merely for the Wednesday sessions on construction and maintenance. Conditions decree that the engineers form the substantial backbone of the highway organization of the country. Those who will grasp the opportunities are not the ones whose knowledge stops with materials, cross-sections, and methods of construction and maintenance. Legislation is the foundation of all highway work, while the attitude of the user (especially represented by the very aggressive automobile interests) will play a great part in the future of our highway systems.

The session on national aid will require close watching by well-balanced men, free from the trammels of politics and commercial influences, while the resolutions coming up on the last day, proclaiming to the country at large the conclusions of the congress, demand their scrutiny, as they will ask the support of the technical men present. The resolutions will be practically settled in committee, but the committees will be the surer to reflect the tenor of the congress if it is realized that the Saturday attendance will be large and vigorous. It has been definitely announced that an effort will be made to agree on a policy of national aid; on the formation of a body to codify and simplify existing state highway laws, to the end that antiquated and contradictory laws may be superseded, and to arouse the participants to a realization of the part that maintenance must play in our road scheme. Engineers have, therefore, been forewarned of the matters to be taken up, and their failure to attend in large numbers and to stay through the congress will not only be evidence of dereliction of duty but of failure to appreciate the part they may and should take in the development of our highway system.

Highway authorities, too, should be alive to the educational advantages of the congress. The best investment they can make is to send adequate delegations of their responsible officials.

Psychology and the Contractor

San Francisco has recently adopted a bonus and penalty form of contract under which, the city engineer writes to the mayor, very satisfactory results are being secured as to completion of work on time. He notes, for example, that on a street-railway contract the time was cut from 45 days allowed to 25 days, while on a similar contract 48 days sufficed for completing work for which 60 days had been allowed.

These results have probably often been duplicated, and mention is made of them here principally to call attention to the psychological effect of the bonus and penalty clause, though certain other phases are briefly discussed.

As a plain business proposition one would think that a contractor with a fixed-sum contract would rush work through in order to release his plant and use it elsewhere. It is the ordinary business method of turning over one's capital as many times as possible. As a fact, however, while this does theoretically appeal to the contractor—in that he recognizes its inherent economies—practically it makes very little difference in his pace. Custom and the particular types of plant used have set a certain speed and so long as that is maintained very little study is given to the elimination of small inefficiencies and the saving of minutes here and there. The release of his plant and the early receipt of full payment do not give just the sort of stimulus that is needed to make the contractor grudge the small losses.

The "hanging up" of a bonus, however, invests the job with the spirit of a game. Not only is there a schedule—he probably had that before—which it will be a satisfaction to beat, but a monetary prize to win. The bonus seems to be a challenge to him to "get under" the mark set, and with the love of a contest inherent in human nature he accepts the challenge. A contractor to whom $1000 is a bagatelle will chuckle with delight over the earning of a bonus of that amount and brag about it to his friends. He will bend every effort to get it, spurring on his organization and tuning up his equipment to the top notch. The game makes him critical of even small delays, and inefficiency in the use of equipment grows intolerable. The purse looms big and keeps him at it. Oftentimes in his interest in the bonus he fails to recognize that the savings through better management amount to more than the monetary prize. It is recognized, of course, that emergency work, done under very high pressure, is generally costly; but it is the general run of contract in which the completion date is important that is here considered.

While undoubtedly a bonus clause does aid materially in securing the completion of work on or before schedule time, it must not, therefore, be considered as commendable in all sorts of contracts. Often there is no special need for hasty construction or harm from delay, while in other cases the schedule may be so liberal and the conditions as to materials and labor so favorable that there is every likelihood of a competent contractor finishing on time.

The setting of a fair completion date under a bonus and penalty clause, moreover, is not a simple matter. If the time estimate is too liberal, money is unnecessarily spent, while if too short the contract figures will be correspondingly high, and good men may refuse to bid, leaving the work to those who take "long chances." Presumably if the time is very short there will be some counterbalancing benefit to the owner from early completion.

With good records of construction performance it is possible to set fair schedules that will avoid the difficulties and, when the completion date is imperatively set, to name a per diem bonus or penalty that will be an incentive to the contractor and be profitable to the owner.

Organized Aeronautical Research

An investigation of much engineering and scientific interest is shortly to be concluded by a commission appointed last winter by the President to report upon the feasibility of a national aeronautical laboratory. The development of this movement is outlined in a recent issue of the "North American Review" by Dr. A. F. Zahm, a well-known authority upon aerodynamics associated with the Bureau of Standards and holding membership in the commission. It is well known that this country has dropped considerably behind France, Germany, Russia and Italy in aeronautical achievement, whether for military or commercial service, and the importance of more vigorous work, sustained by ample funds, can easily be demonstrated. The national aeronautical laboratory plan appears to offer a method of securing more efficient development, and the conditions for its establishment, as described by Dr. Zahm and in the writings of Capt. W. I. Chambers, who is in charge of aviation in the United States Navy, seem unusually favorable.

Aviation has come to stay, regardless of the penalties it exacts from inexperienced, careless and even at times from efficient operators of air craft. The long list of fatalities within the past two or three years is an indisputable demonstration that man has yet to achieve the complete mastery of air transportation, but it can no more hold back the ultimate solution of the problems of flight than deaths by drowning at summer resorts can prevent people from learning to swim. A revolutionary method of travel has been born, and its military and economic values are potentially so great that nothing can stop its progress. It is certain that co-operative research under the general direction of an impartial tribunal will be a powerful factor in establishing this fascinating art upon safer foundations, and that by concentrating our resources the general advance will be both steadier and faster than under present rather haphazard conditions. In the proposed laboratory a staff of trained specialists, provided with adequate apparatus, would furnish physical constants, laws, formulæ and experimental data of substantial and permanent value to the engineer, the aviator, inventor and manufacturer; the laboratory would enable complete and reliable tests and reports to be made upon all classes of air craft that may be worthy of study and development, and it would preferably be located adjacent to a governmental flying ground, surrounded by ample manœuvering space over land and water, provided with hangars and shops open to all civilians worthy of assistance. The knowledge gained as to the art could be disseminated by publications, exhibits, conferences and lectures. By placing the work of the laboratory under the direction of a council in addition to a director and his staff, it is felt that large and enduring results would be assured. Work under such supervision in Europe is amply repaying the cost of its foundation. Dr. Zahm points out at length his concurrence with Captain Chambers' opinion that the grounds of the Smithsonian Institution provide an ideal location for the laboratory, and outlines the organizations of this character abroad which are contributing to the advancement of the art of aeronautics.

To the engineer, the proposal is of interest largely in connection with the structural, power, and stability problems of the aeroplane. Fundamentally, however, a national aeronautical laboratory would afford an opportunity for the United States to take a fitting part in the development of an art which in time may result in a revolution in transportation methods.

Steel Highway Bridge Specifications of the Office of Public Roads

The idea of having a definite standard, below which the highway bridges throughout the nation should not fall, is a good one. It is likely that the results of a standard specification will be greatest in the remote localities where town and county officials have little knowledge of either engineering requirements or proper bridge construction and have generally been largely at the mercy of combined or competing contractors. Any well-directed educational effort to inform them in the essentials of correct practice is desirable.

While the specifications of the Office of Public Roads, printed in the last issue of the Engineering Record, are of average merit as compared with those issued from time to time by engineers, bridge companies, and others, they are not as good as they easily might be. Though not complicated, they are far beyond the comprehension of the average town or county official, and are for the guidance of the specialist, and, therefore, require the services of an experienced bridge engineer to make them valuable. They should be accompanied by a statement that competent engineering services in addition to these specifications are essential to successful bridge building.

As the specifications are issued by a bureau of the national government and will be widely accepted, their requirements should be very carefully considered with reference to cost and resulting efficiency. With this in view certain clauses will be briefly considered.

The minimum depth to length ratios for rolled beams (1/20), plate girders (1/12) and trusses (1/10) are those generally permitted for railway bridges and are all larger than are required for highway loads.

The clauses regarding the amount and assumed distribution of the concentrated live loads are good, while the advisability of using the same unit stress for compression as for tension is open to serious question. The trend of the best modern specifications is to limit the compressive unit stress to not over 14,000 lb. for small values of l/r. As the reduced compressive unit stress is applied to the gross section of compression members, and the tensile unit stress to the net, in a bridge with a short panel length the gross area of the compression chord would be less than that of the tension. The permission to use compression members in certain cases with an unsupported length of 140 times their least radius of gyration is to be commended. There is no question that a compression member designed for a unit stress of $(16,000 - 70\ l/r)$ will be safe and permanent even at a higher limit of l/r than 140.

The clauses prescribing the unit stresses in members subject to flexure are very loosely drawn. For example, a unit stress of 16,000 lb. on the extreme fiber of built-up girders is specified in the same clause which sets 12,500 lb. as the extreme fiber stress in rolled beams. This implies that the section modulus of all the material in the cross-section should be used, while under "Proportioning Plate Girders" it is specified that the flanges shall be assumed to take all the bending moment, which implies that the flange stress be determined by the usual approximate method. There will, in general, be no necessity for splicing the web of a girder under 50 ft. in length, and, further, proper splicing of the web is always possible; there is, therefore, no reason for neglecting the resistance of the web. The use of a unit stress of only 12,500 lb. on rolled beams is not in accordance with the best practice, and the specifications having the greatest authority permit 16,000, or the same as for built-up girders. It may be noted that the New York Building Code specifies a unit stress of 16,000 for rolled and 14,000 for built-up beams.

The limiting of the spacing of floor joists to 3 ft. is, perhaps, proper for timber floors, but the limit is too low for reinforced-concrete slabs or buckle-plate floors.

There is, perhaps, no single item which adds so much to the cost of bridge work as the field riveting. The unit stresses specified for shop and field rivets in bearing are 20,000 and 15,000 lb., respectively, and in shear 10,000 and 7,500 lb. These values for shop rivets are 17 per cent, and for field rivets 25 per cent less than those required by the American Railway Engineering Association's specifications. The stipulation of such low unit stresses for rolled beams and rivets will, in general, produce a structure much more expensive, and very little, if any, better than it would be if designed under the railway engineering association's specifications—than which none has greater authority. It is unlikely that the new specifications will have anything like the universal use for which they are intended on account of these costly but not efficiency-producing requirements.

The requirements for rivet pitch are the conventional ones, except for three innovations, which are not to be commended: (1) The definite statement of the method to be used in determining the number of rivets necessary to connect the vertical legs of the flange angles to the webs of plate girders is very nearly correct if the action of the web to resist bending is neglected and if there be no vertical load to be transferred to the web. Strict adherence to this rule might in certain cases give too few rivets. (2) The requirement that in no case shall the pitch of such rivets exceed 4 in. is very wasteful. There is no reason for such a small minimum spacing in the unloaded flange or flanges of a girder. (3) With reference to splice plates, the number of rivets theoretically required on each side of the joint must be arbitrarily increased 33 1/3 per cent for each filler under the splice plates. It is needless to say that no scientific detailing can be done on such a basis. There is nothing to be gained by crude rules governing matters with which only the skilled specialist should deal.

The remaining clauses are in general those of conventional practice. In order that the specifications shall accomplish their object—of securing a better class of highway bridges—they should be revised in several important particulars, and emphasis laid on the necessity of employing competent engineers on each bridge.

Sewage Disinfection in Philadelphia

Details of Apparatus for Treating Effluent of Pennypack Creek Works

By W. L. Stevenson, Assistant Engineer, Bureau of Surveys, Philadelphia

Two-thirds of the water supply of Philadelphia is obtained from the Delaware River. The water is passed through preliminary and slow-sand filters and disinfected with calcium hypochlorite before delivery to the consumer.

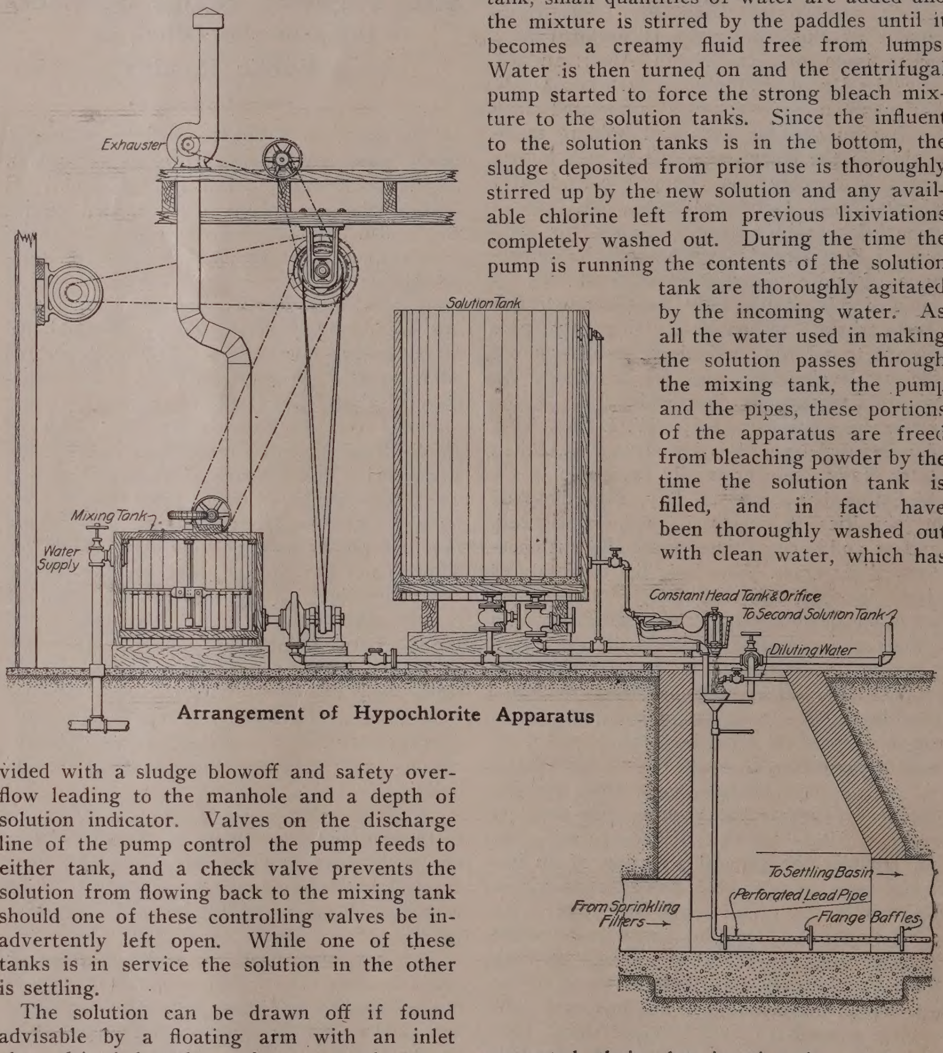
Pennypack Creek enters the Delaware River, which is tidal, about 2000 ft. below the intake of the water filters. Upon the watershed of the creek are situated the village of Holmesburg and two municipal penal institutions. The crude sewage of about 10,000 persons was, therefore, formerly discharged into the tidal flow of the Delaware River, immediately adjacent to the source of the city's water supply. In order to remove this pollution there has been built and put into operation by the Bureau of Surveys, of which Mr. George S. Webster is chief engineer, the Pennypack Creek sewage-treatment works, which consist of a grit chamber, coarse screens, two Emscher tanks, 1 acre of percolating filters, a disinfection apparatus and a final settling basin. (The works were described in the Engineering Record of Jan. 14, 1911, page 48.)

In designing the disinfection apparatus an attempt was made to overcome certain difficulties noted in most installations of this type, among which the following may be noted: Calcium hypochlorite exerts a very corrosive action on wood and most metals, so that frequent renewals of tanks and piping are required; the dust arising when cans of bleaching powder are opened and during the making of the solution is very irritating to the eyes and noses of the men engaged in operating the plant; in small installations irregular flow of the solution is common, due to clogging of the measuring orifice by imperfectly settled solutions of the bleach or flakes of calcium carbonate formed in the solution tanks by absorption of carbon dioxide from the air; inadequate mixture of the disinfecting solution and the sewage lowers the efficiency of the process.

At the Pennypack Creek works the effluent of the percolating filters flows in a vitrified clay pipe to the final settling basin, which serves also as a storage reservoir for the action of the disinfectant. The apparatus is housed in a frame building 14 x 15 ft. by 10 ft. high, situated over a manhole on this pipe line. It consists of water service pipes, electric motor, centrifugal pump, dust exhauster, mixing tank, solution tanks, constant-head orifice tank, diffusion devices, and the necessary piping and shafting, as shown diagrammatically in the drawing on this page.

Usually the mixing tank is located above the solution tanks so as to have a gravity flow; this requires the use of steps and makes it necessary for the operator to carry the dry bleach up about 10 or 12 ft. In this apparatus the mixing tank is located 6 in. above the floor, so that its top is about level with the top of the drum of the bleach. It is a white cedar tank 3 ft. in diameter and 2 ft. 6 in. deep, lined with cement mortar plastered on metal lath fastened to the inside of the tank. It has a wooden cover, a segment of which is hinged for adding the dry bleach. In a circular hole in the top is fitted the dust pipe leading to a Sturtevant exhauster, whose discharge is connected to a terra-cotta chimney.

A water connection is made to the mixing tank near its top. The stirrer consists of eight steel teeth fastened to a horizontal arm driven by worm gearing upon the top of the tank. The discharge is in the side and near the bottom of the tank and connected with the suction of a $1\frac{1}{2}$-in. centrifugal pump set below the bottom of the mixing tank, so that it does not require priming. The force main of the pump is connected to the bottom of the two solution tanks. These are also of white cedar, with a cement lining, and are raised 18 in. above the floor; each tank measures 4 ft. in diameter and is 6 ft. deep. Each is provided with a sludge blowoff and safety overflow leading to the manhole and a depth of solution indicator. Valves on the discharge line of the pump control the pump feeds to either tank, and a check valve prevents the solution from flowing back to the mixing tank should one of these controlling valves be inadvertently left open. While one of these tanks is in service the solution in the other is settling.



Arrangement of Hypochlorite Apparatus

The solution can be drawn off if found advisable by a floating arm with an inlet about 6 in. below the surface, so as always to supply the constant-head orifice box with the clearest solution, free from flakes of calcium carbonate which often float on the surface or sludge which settles on the bottom of the tank. The solution is added to effluent of the percolating filters. The constant-head orifice tank is enameled on the inside and the working parts are made of bronze.

Experiments conducted by the Bureau of Surveys during 1909 and 1910 in the sewage-testing station demonstrated the importance of obtaining an intimate mixture of the hypochlorite solution with the sewage to be disinfected, due to the inefficiency of natural diffusion. To avoid the continual use of power for a mechanical mixer under the disinfection house the bleach solution, as it flows from the orifice box, is diluted with a stream of water, and the very dilute bleach solution flows to a lead pipe supported on flanges, resting on the bottom of the terra-cotta pipe which conveys the effluent of the percolating filters to the final settling basin. The very dilute bleach solution is thoroughly mixed with the sewage by flowing out through a large number of small holes in the lead pipe and by the baffling action of the flanges upon the lead pipe.

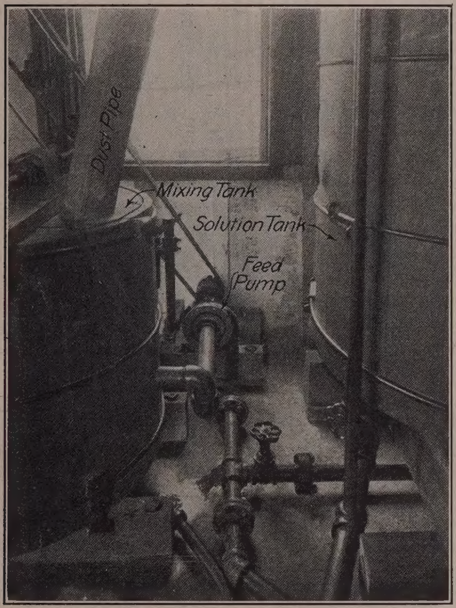
The power for driving the stirrer in the mixing tank, the exhauster and the pump is obtained from a $1\frac{1}{2}$-hp, 220-volt motor.

The operation of the disinfection apparatus is as follows: A drum of bleach is placed beside the mixing tank and under a dust hood connected to the exhauster. With the exhauster running, the proper quantity of hypochlorite is weighed out under the canvas cone. The powder is then emptied into the mixing tank, small quantities of water are added and the mixture is stirred by the paddles until it becomes a creamy fluid free from lumps. Water is then turned on and the centrifugal pump started to force the strong bleach mixture to the solution tanks. Since the influent to the solution tanks is in the bottom, the sludge deposited from prior use is thoroughly stirred up by the new solution and any available chlorine left from previous lixiviations completely washed out. During the time the pump is running the contents of the solution tank are thoroughly agitated by the incoming water. As all the water used in making the solution passes through the mixing tank, the pump and the pipes, these portions of the apparatus are freed from bleaching powder by the time the solution tank is filled, and in fact have been thoroughly washed out with clean water, which has prevented their deterioration by corrosion.

As a protection to the tanks, pipes and valves against the corrosion action of the bleach, they were thoroughly coated with Minwix clear waterproofing, a natural paraffin preparation, resistant to the corrosive action of the bleach.

Where percolating filters are dosed from a tank which alternately fills and discharges, the flow from the underdrains of the filter varies synchronously with the dosing tank, and for economical use of the disinfectant it should be added in proportion to the rate of flow of the effluent. But in the works, of which the above-described apparatus is a part, the undulating head upon the nozzles is caused by a butterfly valve in the main distributing line between a tank in which the effluent of the Emscher tank is maintained at a nearly constant elevation and the percolating filter. The rate of flow of effluent from the filter is, therefore, more uniform than usual, and a uniform rate of flow of the bleach solution is used.

Due to the freshness of the crude sewage, the efficiency of the Emscher tanks and the percolating filters, the effluent to be disinfected is well oxygenated and has a lower avidity for oxygen than is usual. These conditions, together with the complete admixture of the diluted bleach solution with the filter effluent, have made it possible to produce an almost sterile effluent with a minimum amount of bleach. When the works were first put in service and the percolating filters were immature, and no laboratory facilities were available, an amount of bleach was added to insure a low bacterial content in the final effluent. The quantity was gradually decreased, as shown in the accompanying table:



Piping between Tanks

1913	Lb. dry bleach per million gal.	Parts per million avail. chlorine added	Cost for bleach per million gal.	Final effluent contained bacteria per c.c. on agar in 24 hours at 37 deg. C. — Total numbers	Acid formers	Resembling B. coli.
Jan. 22 to 30	92.6	3.8	$1.36	..	..	..
Feb. 1 to 6	54.5	2.2	0.80	7	0	0
Feb. 7 to 11	42.9	1.8	0.63	3	0	0
Feb. 12 to 13	33.5	1.4	0.49	6	0	0
Feb. 14 to Mar. 31	23.4	0.9	0.36	38	4	2
Apr. 1 to 2	21.0	0.9	0.34	12	2	0
Apr. 3 to 30	20.5	0.9	0.34	14	1	0
May 1 to 21	19.8	0.84	0.32	10	0	0

During the period from April 30 to May 1 there were two occasions when the distributing system of the percolating filters was being blown out and samples were taken at the same time. The laboratory found on May 9 200 organisms per cubic centimeter resembling B. coli and 150 on May 16. These data are omitted in the table, as the conditions only lasted a few minutes and the inclusion would obscure the general average.

The Pennypack Creek sewage-disposal works were designed by Mr. George E. Datesman, principal assistant engineer; the disinfecting apparatus was designed by the writer.

The Linnakoski Waterfall and property in its vicinity in Finland have been bought by the Russian-Asiatic Bank at St. Petersburg, Russia, for the sum of $231,600. It is expected to develop the power and transmit it to the Russian capital.

Lime Sterilization of Water

Results of Research Work Conducted at the Columbus Water-Purification Plant

By Charles P. Hoover, Chemist in Charge, and Russell D. Scott, Assistant Chemist

At the Columbus water-softening and purification plant lime is used to remove the temporary hardness of the water. It has always been the policy at this plant to add the lime in quantities just sufficient to neutralize the free and half-bound carbonic acid and to precipitate the magnesium. The utmost care has always been exercised in order to reduce the temporary hardness to the lowest possible figure and still not leave residual or excess lime in the softened water. During the four years that the plant has been in operation, the average chemical analysis of the raw river water (expressed in parts per million) has been as shown in Table 1.

Table 1.—Chemical Analysis of Raw Water, Parts Per Million

Total alkalinity (temporary hardness)	151
Incrustants (permanent hardness)	96
Total hardness	247
Total magnesium	21
Free carbonic acid	1
Half-bound carbonic acid	66
Turbidity	69
Color	32

The water has received an average chemical treatment, expressed in grains per gallon, as follows: Lime, 7.6; soda ash, 4.2; alum, 1.5. After the addition of the chemicals to the water it passes through baffled mixing tanks, then into settling basins and after from 15 to 20 hours' sedimentation the water is filtered through mechanical sand filters.

The average analysis of the softened water, expressed in parts per million, for the past four years is shown in Table 2.

Table 2.—Analysis of Softened Water, Parts Per Million

Total alkalinity (temporary hardness)	45
Incrustants (permanent hardness)	40
Total hardness	85
Total magnesium	10
Bicarbonate alkalinity	3
Normal carbonate alkalinity	42
Caustic alkalinity	0
Turbidity	0
Color	7

It has been observed that bacterial tests, made for the presence of intestinal bacteria, in the softened water, collected from the outlet of the sedimentation basins, are negative 92 per cent of the time in 1 cu. cm. A series of laboratory tests was made in order to determine the agencies or factors responsible for the elimination of intestinal bacteria in the softened water. The following phases of the subject were studied: 1. Is the action mechanical? In other words, are the bacteria entangled with the precipitated carbonates and dragged down mechanically?

2. Is the action due to the presence of normal carbonates of calcium or magnesium?

3. Is the action due to the presence of basic carbonate of magnesium?

4. Is the action due to the absence of free and half-bound carbonic acid?

5. What is the bacterial effect of free or excess lime in the treated water?

6. Do the organisms perish because the organic matter has been removed and not enough food supply is left in the treated water?

Chemical Action of Lime Added to Water

Before presenting the outline of the experiments a brief explanation of the chemical action of lime when added to a hard water will be given, because there seems to be some confusion in reference to the chemical tests used to determine the presence of bicarbonates, normal carbonates and excess lime, in lime treated waters. When lime is added to a hard water containing calcium and magnesium bicarbonates and magnesium sulphate its action is twofold. It neutralizes the free and half-bound carbonic acid, thus precipitating the calcium as calcium carbonate, and converts the magnesium to the insoluble hydrate form. Its action on the incrusting (sulphate, chloride and nitrate) magnesium results in the formation of an equivalent amount of calcium incrustants. When lime is added to a water containing only calcium salts, it is necessary to apply only sufficient lime to neutralize the free and half-bound carbonic acid. The chemical reactions are:

$$\begin{array}{lll} \mathrm{CaCO_3CO_2} & + \mathrm{Ca\ (OH)_2} = & \mathrm{CaCO_3} + \mathrm{H_2O} \\ \mathrm{MgCO_3CO_2} & + \mathrm{Ca\ (OH)_2} = & \mathrm{MgCO_3} + \mathrm{CaCO_3} + \mathrm{H_2O} \\ \mathrm{MgCO_2} & + \mathrm{Ca\ (OH)_2} = & \mathrm{Mg\ (OH)_2} + \mathrm{CaCO_3} \\ \mathrm{CO_2} & + \mathrm{Ca\ (OH)_2} = & \mathrm{CaCO_3} + \mathrm{H_2O} \\ \mathrm{MgSO_4} & + \mathrm{Ca\ (OH)_2} = & \mathrm{Mg\ (OH)_2} + \mathrm{CaSO_4} \end{array}$$

The only analytical data necessary to determine the amount of lime required to absorb the free and half-bound carbonic acid and to precipitate the magnesium are free CO_2, half-bound CO_2 (44 per cent of the alkalinity), and total magnesium. The following formula for determining the amounts of lime required gives good results: Lime required, grains CaO per gallon, equals free and half-bound CO_2 (parts per million) x .074; or total magnesium x .136.

Measurement of Caustic Alkalinity

After the water has been treated with lime a chemical analysis will show whether or not the proper amount of lime has been applied. The production of a red color when phenolphthalein is added to a lime treated water does not mean that too much lime has been added, for water that has had no lime added to it will show a red color to phenolphthalein under certain conditions. For instance, if a hard water is boiled until all of the free and half-bound carbonic acid is driven off, the boiled water will react red to phenolphthalein, the red color being due to the presence of the slightly soluble normal carbonates of calcium and magnesium. The silver nitrate test for excess lime is not trustworthy because of color complications when chlorides are present. The alkalinity of natural waters ordinarily includes the carbonates of calcium and magnesium. It may also include carbonates of sodium and potassium and, if the water is overtreated with lime, the water will contain caustic alkalinity. The caustic alkalinity may be determined by the following scheme of analysis: 1. Determine total alkalinity, using methyl orange, or erythrosine as indicator. 2. Determine alkalinity, using phenolphthalein as indicator.

If the water contains more than one-half as much alkalinity to phenolphthalein as it does to methyl orange or erythrosine, then the water contains excess lime, or caustic alkalinity, because the analysis made with phenolphthalein indicates all the hydrate but only one-half of the carbonates, for the sulphuric acid used in making the titration causes the liberation of an equivalent amount of carbonic acid, which reacts acid to phenolphthalein.

The rule for calculating the caustic alkalinity, according to the standard methods of water analysis adopted by the American Public Health Association is to multiply the phenolphthalein alkalinity by 2. From this result subtract the total alkalinity. The difference equals the caustic alkalinity. Table 3 shows the relation between alkalinity by phenolphthalein and that by erythrosine or methyl orange in the presence of bicarbonates, carbonates and hydrates.

Table 3.—Results Expressed in Parts Per Million

Suppose the alkalinity to methyl orange or erythrosine to be	And the alkalinity to phenolphthalein	Then the analysis would show Bicarbonates	Normal carbonates	Excess lime or caustic alkalinity
44	0	44	0	0
44	20	4	40	0
44	22	0	44	0
44	24	0	40	4
44	44	0	0	44

Excess Lime Method

Dr. A. C. Houston, chemist of the Metropolitan Water Board, London, England, in the eighth research report of the Metropolitan Water Board, proposed an excess of lime method of sterilizing water. His conclusions were founded on his observations that quick lime added to raw Thames water in the proportion of 1 part quick lime to 5000 parts of water, kills B. coli in 5 to 24 hours and inferentially, but certainly, the microbes also of epidemic water-borne diseases, for example, the typhoid bacillus. He proposed purposely to overdose a part of the water with lime so as to bring about a known bactericidal effect and then, after a suitable interval, to mix this portion with enough water, adequately stored or sterilized with ozone or hypochlorite, to neutralize the excess lime. He states in his report that the excess lime is responsible for the germicidal action and that if just enough lime is used to neutralize the bicarbonate alkalinity of the water, no bactericidal action is effected.

It is noted in looking over the results of Dr. Houston's work that excess lime was indicated by the red color produced when phenolphthalein was added to the treated water. The fallacy of this method of measuring excess lime has been stated in a previous paragraph and needs no further comment, but we suggest that this method of chemical technique may have led Dr. Houston to believe that he was using a large excess of lime when in reality he was measuring the normal carbonates of calcium and magnesium and not excess lime.

Sterilizing Action Not Necessarily Due to Toxic Effect of Lime

The results of bacterial tests made on lime softened water, containing no excess of lime, at the Columbus water softening and purifying plant during the past four years and also the results of numerous laboratory experiments lead us to believe that the action is not necessarily due to the toxic effects of the lime but that sterilization is effected when just enough lime is used to neutralize all of the free and half-bound carbon dioxide in the water. Bacteria belonging to the colon or typhoid group seem to require carbonic acid for their existence and development. If two samples of water, one containing carbonic acid and the other having no carbonic acid, be inoculated with typhoid or colon bacilli these organisms will live in the carbonate water but die in the water free from carbonic acid.

Samples of softened water, containing no free or half-bound CO, or free lime, collected from the outlet of the sedimentation basins at the Columbus plant were divided in two portions. Both portions reacted alkaline to phenolphthalein, i.e., turned red when phenolphthalein was added.

Table 4.—Results of Bacterial Tests

Chemical results are expressed as parts per million Sample No.	Lime added, grains per gal.	Total Alkalinity to Erythrosine	Alkalinity to Phenolphthalein	Bicarbonate Alkalinity	Normal Carbonate Alkalinity	Caustic Alkalinity or Excess Lime	Average number of color bacilli per c.c. 5 hours contact Sample shaken	24 hours contact Supernatant solution	 Sample shaken
1 to 12	0	170	0	170	0	0	3000	1200	8000
12 to 27	6.0	54	17	20	34	0	300	300	400
27 to 34	7.0	44	24	0	40	4	10	2	0
34 to 39	8.5	48	31	0	34	14	2	0	0
39 to 53	10	77	64	0	26	51	0	0	0

After introducing carbonic acid into one portion the reaction was changed from alkaline to acid to this indicator. Both portions were inoculated with crude sewage and it was found, by test, that 5000 intestinal bacteria per cubic centimeter had been introduced into the sample. After 48 hours, it was found that the alkaline water was practically sterile while the acid or carbonated water contained greater numbers of intestinal or sewage bacteria than were originally inoculated into the sample. It was also found in experimenting with samples containing from 1 to 2 parts per million to 400 parts per million CO_2 that the greater the charge of carbonic acid, the more favorable the water became as a medium for intestinal bacteria.

Table 5.—Analysis of Raw Sewage from Girls' Industrial School

Quantity of sewage tested	Gas production in lactose bile. Period of contact 5 hours	24 hours	48 hours	72 hours
10 c.c.	+	+	+	+
1 c.c.	+	+	+	+
1/10 c.c.	+	+	+	+
1/50 c.c.	+	+	+	0

Table 6.—Results after Lime Treatment, Girls' Industrial School

Period of contact..........		5 hours			24 hours			48 hours			72 hours		
Grains per gallon of lime added		8.5	9.3	11.0	8.5	9.3	11.0	8.5	9.3	11.0	8.5	9.3	11.0
Gas production in Lactose Bile Solution	10 c.c.	+	+	+	+	+	+	+	+	0	0	0	0
	1 c.c.	+	+	+	+	+	0	+	+	0	0	0	0
	1/10 c.c.	+	+	+	0	0	0	0	0	0	0	0	0
	1/50 c.c.	+	+	+	0	0	0	0	0	0	0	0	0

In order to show that the use of lime was not the essential factor in producing a water that would not be favorable for bacterial development, or that the toxic action was due to lime, samples of well water were boiled until free from carbonic acid. These boiled well water samples showed an alkaline reaction to phenolphthalein, whereas the unboiled samples containing CO_2 reacted acid to this indicator. Both the boiled and unboiled samples were inoculated with large numbers of typhoid and colon bacilli, and it was found that the bacterial growth was not disturbed in the carbonated portion but that the boiled portion free from carbonic acid became practically sterile in 48 hours' time.

Table 7.—Analysis of Raw Sewage, Marble Cliff Plant

Gas production in lactose bile solution Quantity of Sewage Tested	Period of Contact 4 hours	 24 hours	 48 hours	 72 hours
10 c.c.	+	+	+	+
1 c.c.	+	+	+	+
1/10 c.c.	+	+	+	+
1/50 c.c.	+	+	+	+
1/500 c.c.	+	+	0	0
1/2500 c.c.	+	+	0	0
1/10000 c.c.	+	+	0	0

Sterilizing River Water with Lime

Fifty-three 1-gal. samples of river water were inoculated with 25 cu. cm. of crude sewage, introducing from 3000 to 8000 colon bacilli per cubic centimeter and an average of 46,000 total numbers of bacteria. The samples so treated were vigorously shaken at 30-minute intervals for 5 hours and at the end of this period the total numbers of bacteria were determined and also quantitative lactose bile presumptive tests for colon bacilli were made. The samples were then allowed to stand for 19 hours and a second bacterial analysis made. After this test was finished the samples were vigorously shaken and a third analysis made. Over 1000 bacterial tests were made on these samples and the summary of the results of these tests is shown in Table 4.

The average total numbers of bacteria present in the lime-treated water was 12,000 per cubic centimeter. The results indicate that the lime has a selective action. Intestinal bacteria are destroyed but the percentage reduction of total numbers of bacteria is not high. Intestinal bacteria are killed and not simply removed by the precipitated carbonate, because the numbers of intestinal bacteria were no higher in the samples that were shaken than they were in the supernatant samples. Twenty-four hours' contact is not sufficient to insure sterilization unless the water is treated with an overdose of lime.

Effluents from the sewage disposal plant at the Ohio Girls' Industrial School and from the sewage plant at the village of Marble Cliff, Ohio, were treated with lime. The sewage plant at the Girls' Industrial School comprises septic tank treatment, sprinkling filters and slow sand filtration. The Marble Cliff Plant consists of septic tanks, coke contact beds and coke filters. The analysis of the raw effluent from the girls' school is shown in Table 5.

Samples were treated with 8.5, 9.3 and 11 grains of lime. Eleven grains of lime proved just enough to neutralize the temporary hardness and leave no excess lime.

Table 8—Bacterial Results After Lime Treatment, Marble Cliff Plant

Period of Contact.		4 hours				24 hours				48 hours				72 hours			
Grains per Gal. of Lime		22	24	26	28	22	24	26	28	22	24	26	28	22	24	26	28
Gas production in lactose bile solution	10 c.c........	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	1 c.c........	+	+	+	0	+	+	0	+	+	+	+	+	+	0	+	0
	1/10 c.c........	+	+	+	0	+	0	0	+	0	0	0	0	0	0	+	0
	1/50 c.c........	+	+	+	0	0	0	0	0	0	0	0	0	0	0	0	0
	1/500 c.c........	+	+	+	0	0	0	0	0	0	0	0	0	0	0	0	0
	1/2500 c.c........	+	+	+	0	0	0	0	0	0	0	0	0	0	0	0	0
	1/10000 c.c........	+	0	+	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 6 shows the bacterial results obtained after the lime treatment.

The results show that "excess lime" is not necessary, provided sufficient period of contact is allowed. The bacterial analysis of the raw effluent from the Marble Cliff Plant appears in Table 7.

The alkalinity of this effluent was 425 parts per million and samples were treated with 22, 24, 26 and 28 grains per gallon. Twenty-two grains introduced no caustic alkalinity; 24 grains, 1.4 grains caustic alkalinity; 26 grains, 2.5 grains caustic alkalinity; 28 grains, 4.5 grains caustic alkalinity.

Table 8 shows the bacterial results obtained after lime treatment.

When large amounts of organic matter are present the action is not complete.

Viability of Typhoid Bacilli in Lime-Softened Water and Double Distilled Water

Nine samples of lime-softened water and seven samples of double distilled water were inoculated with typhoid organism. Six strains of these organisms were used and they were obtained from six different laboratories.

Table 9.—Average Chemical Analysis of Samples

	Total Alk.	Bicarb. Alk.	Normal Alk. Carb.	Caustic Alk.	Free CO
Distilled HO........	0	0	0	0	+
Lime-softened HO..	75	3	72	0	0

From 70,000 to 100,000 typhoid bacilli were introduced into these samples and 24 hours after being inoculated the numbers present in the distilled water had not decreased, whereas the lime-softened water samples had become practically sterile. Samples of distilled water boiled for 30 minutes (so as to free the water from CO_2) and then carefully cooled so that no carbonic acid would be absorbed, were inoculated with typhoid organisms, and 24 hours after inoculation samples were sterile, indicating that although the water may be free from organic matter, typhoid organisms will live for a time provided the water contains free carbonic acid.

Table 10 shows the results of another series of experiments on the viability of B. typhosus in lime-softened water. Each day for 9 consecutive days typhoid bacilli were inoculated into samples of softened water from the outlet of the sedimentation basins at the Columbus Plant.

Table 10.—Chemical Analysis in Parts per Million

					Bacterial analysis of		
						Softened water inoculated with typhoid bacilli	
Oct., 1912	Total alkalinity	Bicarbonate alkalinity	Normal carbonate alkalinity	Excess lime caustic alkalinity	Softened water control	Initially	After 24 hours
20	47	5	42	0	0	180	0
21	52	8	44	0	0	20	0
23	59	7	52	0	0	50	6
24	58	12	46	0	0	165	2
25	64	8	56	0	0	390	0
26	58	2	56	0	0	360	1
27	50	2	48	0	14	3600	1
28	46	0	42	4	0	300	0
29	48	0	48	0	1	3600	0

From Jan. 7 to 15 the average number of B. coli present in the river water averaged 100 per cubic centimeter. From Jan. 7 to Jan. 10 lime was used in quantities sufficient to soften the water and B. coli were absent in 1-cu. cm. portions of water collected from the outlet of the sedimentation basins, and the total numbers of bacteria present at 37 deg. C., 24 hours' incubation, averaged 96. From Jan. 10 to 14 no lime was used and during this period, when the water was receiving no lime treatment, samples from the outlet of the sedimentation basins showed positive presumptive B. coli tests in dilutions of 1 to 25 and the total number of bacteria at 37 deg. C., 24 hours' incubation, averaged 575. Tests again became negative for colon bacilli when lime treatment was resumed, showing that much better bacterial results can be obtained at the Columbus plant when lime is used.

Advantages of Lime Treatment

The intestinal bacteria and pathogenic organisms are killed by lime treatment, rendering the water safe bacterially. The water is softened and soft water is more satisfactory than hard water for practically all purposes.

When lime is added to a water containing calcium and magnesium salts a precipitate of calcium and magnesium hydrate is formed. The precipitated carbonate is pulverulent and is not a very good coagulant, but the precipitate of magnesium hydrate is gelatinous and has about the same coagulating properties as the hydrate precipitates of iron and alumina. This gelatinous precipitate of magnesium becomes entangled with the precipitated carbonate, forming a gummy mass that settles very quickly. If there is no magnesium present in the water, a very small amount of filter alum, aluminum sulphate, will prove effective in hastening sedimentation.

The average turbidity of the river water treated at the Columbus water purification works for the years 1910, 1911 and 1912 was 63 parts per million. After being treated with lime, soda ash and alum the water was allowed to settle for about 12 or 15 hours and the average turbidity of the settled water was less than 5 parts per million and from June 1, 1912, to Jan. 1, 1913, the turbidity averaged less than 1 part per million, the settled water being so clear that the filters were kept in service on several occasions for a period of 7 days without being washed and did not then show a negative loss of head. During the summer months, when the raw water shows a high average hardness, 250 to 350 parts per million, and low turbidity, the clarification is almost perfect.

Turbid waters can be successfully disinfected by softening with lime and then allowing the turbidity to settle out, along with the precipitated carbonates. Turbid water has never been successfully disinfected with hypochlorite because the bacteria embedded in the suspended matter are not destroyed.

The sterilizing action persists indefinitely. In a recent paper on water disinfection by chemical methods (see Engineering Record, Oct. 17, 1912, page 702), Mr. Samuel Rideal states the advantage of using chemicals that persist in their disinfecting action in the following words: "It is at the same time a disadvantage if a disinfectant, however powerful in its first onset, is very evanescent, as many disease germs are strongly resistant and we know that the time factor is of extreme importance in sterilization."

Lime-Softened Water for Swimming Pools

Since lime-softened water is a poor medium for the development of typhoid and colon bacilli, it appeals to the writers that for use in swimming pools a water treated with lime in quantities sufficient to neutralize the temporary hardness and to introduce 2 or 3 grains excess lime would prove to be a very satisfactory and safe water for bathing purposes.

The advantage of caustic water over water sterilized with hypochlorite is that the disinfecting action of the caustic persists and if the water should become contaminated with pathogenic organisms they will soon become attenuated and finally die, because there is no carbonic acid in the water and carbonic acid seems to be essential for their development, whereas a water sterilized by hypochlorite might be all right at the time of being pumped into the pool, but as soon as all the hypochlorite has become dissociated the chemical offers no resistance to the development of disease producing organisms that might be introduced into the water by the bathers.

Sterilization of Water Mains

During the recent floods at Columbus, it was necessary to stop pumping for a period of 24 hours on account of a section of 36-in. pipe being washed out by the flood water. The distribution system was drained and the local health authorities advised the people to boil the water, fearing that the mains would become contaminated with surface water. Knowing from our experiments that B. coli, B. typhosus, B. paratyphosus and intestinal bacteria will not live long in caustic water the method of treatment, after pumping was resumed, was as follows (see Engineering Record, April 12, 1913, page 304):

The water at the plant was treated with enough lime to neutralize the temporary hardness of the water and in addition enough to introduce from 1 to 2 grains caustic alkalinity. Samples of water were collected from all parts of the city and 24 hours after the water taken from all parts of the distribution system showed by chemical tests the presence of excess lime or caustic alkalinity, the water was found to be bacterially pure. This treatment is safe, it does not introduce any taste into the water and there is no evidence, except by chemical tests, to indicate the presence of causticity in the water.

Conclusions

1. When enough lime is added to water to absorb the free and half-bound carbonic acid and to precipitate the magnesium content, the bacteria of the colon and typhoid group are killed in 48 hours after being so treated, provided the water does not contain large quantities of organic matter.

2. The germicidal action is effective in from 5 to 24 hours when an excess of ½ to 1 grain per gallon is added beyond that needed to reduce the temporary hardness to the lowest possible figure.

3. Intestinal organisms will not live in water containing no free or half-bound carbonic acid.

4. Lime-softened water inoculated with typhoid organisms or with crude sewage soon becomes free from them.

5. The action is selective in that certain harmless bacteria grow but the disease producing germs do not.

A Large Hydroelectric Development is now in course of construction in the district of Catalonia, Spain, by the Barcelona Traction, Light & Power Company, organized under the laws of the Dominion of Canada, with a capital of $25,000,000 and a bond issue of $35,000,000 authorized. The company, according to a recent consular report, owns concessions for the development of water powers on the Noguera-Pallaresa and the Segre Rivers and has under construction plants which will develop a total of 140,000 hp. The first of these plants will develop 4000 hp and is located near the town of Pobla. The second plant is near Seros and will have 56,000-hp capacity. The third plant is the most important. It will be located on the Noguera-Pallaresa River above its confluence with the Segre River and which develops 80,000 hp.

Permanent Water Supply for Cherryvale

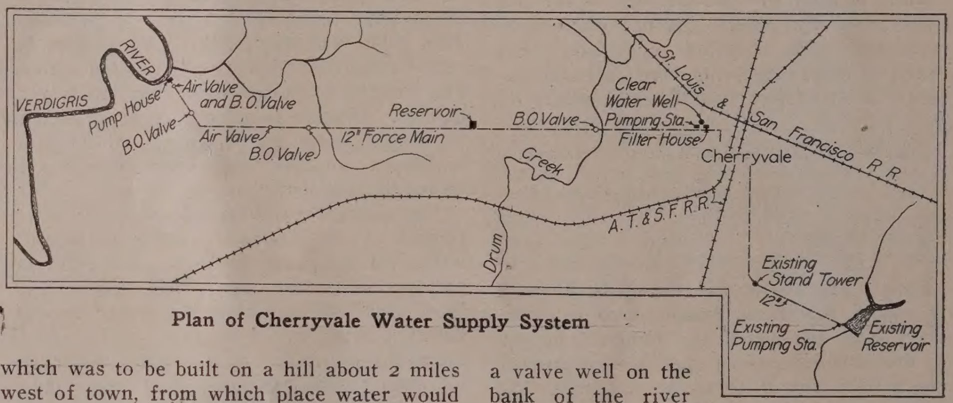
Bringing Water 6 Miles and Filtering It for a Town of 6000 in Kansas

Prior to 1903 the waterworks system for Cherryvale, Kan., consisted of a few mains located in the business district and the source of supply a pond at the edge of town, which collected the rainfall from a watershed containing only a few hundred acres. At that time the oil and gas boom was approaching maximum proportions, and while the quality of the city water was so bad it could be used for only a few purposes, there was a continued shortage. The rapid increase in the population made a demand for a more abundant and potable supply of water as well as extensions to the water mains.

In this section of Kansas there are no ground-water supplies either by means of underflow, springs, shallow wells or artesian wells. Six miles to the west of Cherryvale is the Verdigris River, which is the only stream having a flow of water of any proportions. That this was the only source of supply should have been apparent, according to the engineers, but for some reason the city went 3 miles to the southeast, 9 miles from the permanent source of supply, purchased 80 acres of land and threw an earth dam across a dry ravine. The watershed comprised 1700 acres of sandy farm and grass land. A steam-pumping plant was constructed here, by which water was forced into a standpipe, and general extensions were made to the distribution system. This work was completed in 1904 and 1905, and by 1908, or as soon as the water became in general use over the city, there was another shortage. In the latter part of 1910 Worley & Black were employed to make a study of the water situation and to make a report and recommendations with reference to a permanent water supply.

First an exhaustive study was made to devise means whereby the existing plant could be used as a part of a permanent water supply for the city. The land, dam and reservoir, pump house, pipe lines and machinery had cost more than $50,000 and to recommend any plan which would not include these would mean almost a total loss of this amount to the city. The water in the reservoir, except for being always more or less muddy due to wave action along the shores, which had not been riprapped, and to a bad taste at times due to decayed vegetation, which grew in shallow places, was soft and of fair quality, but it could have been made a potable water by filtering.

The studies indicated that the only permanent water supply for the city was the Verdigris River, and it was recommended that water be taken at a point 6 miles west of town, that an intake, pump house and motor-driven centrifugal pumps be installed here; a 12-in. force main be constructed from the river to an equalizing reservoir which was to be built on a hill about 2 miles west of town, from which place water would flow by gravity to mechanical filters located at a convenient point in town; that a steam-power plant and pumping station be built in conjunction with the filtration plant to pump the water into the standpipe and to generate current for running the motor-driven pumps, 6 miles away.



Plan of Cherryvale Water Supply System

The report and recommendations were accepted and adopted, $105,000 was voted for the improvements, and during 1911 all the work was constructed, except the power house and some changes in the pumping station in the city.

Source of Supply and Intake

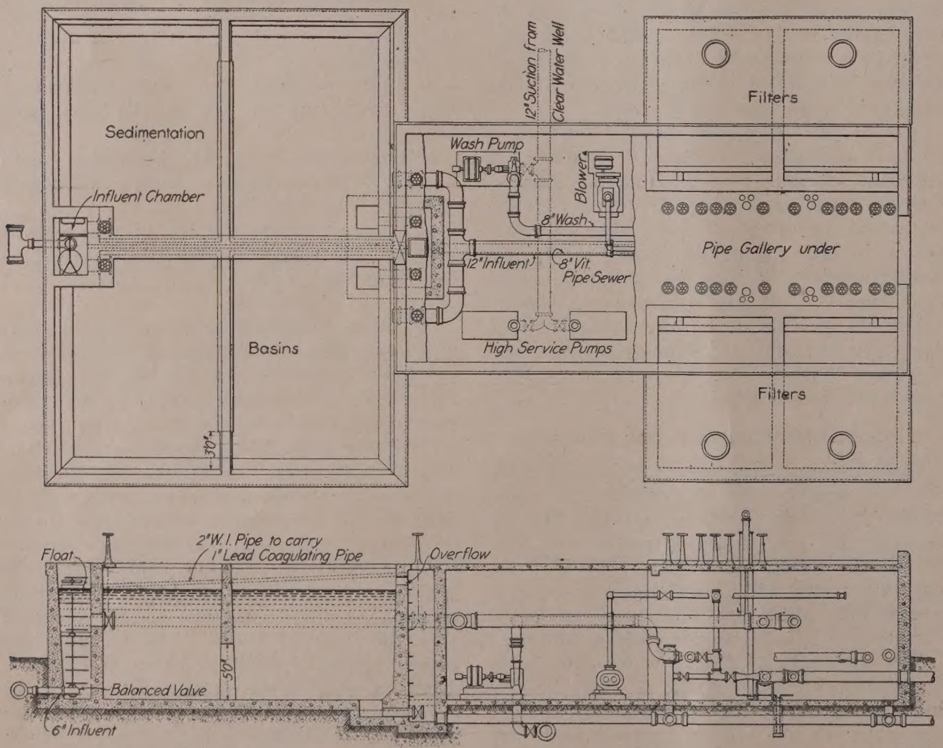
The intake is located about 300 ft. above a riffle which creates a reservoir about 100 ft. in width, 15 ft. average depth and 1 mile long. It is built of concrete and has two separate compartments, into which enter an independent suction main, terminating in a foot valve. The foot valve has a number of small valves working in a deck. The engineers state they find this type the only reliable foot valve for this class of work. Each compartment is provided with a 2-in. line, which is connected to the discharge line of the pumps and carries water at a pressure of 75 lb. The 2-in. lines terminate in a swivel joint so that they can be used in cleaning the foot valves and intake compartments of any silt, leaves or débris which may collect.

The two independent suction lines join in a valve well on the bank of the river and are provided with gates so that both or either can be used.

Pumping Station at Verdigris River

The pumping station at the river consists of a reinforced concrete pump pit, 16 ft. square and 30 ft. deep, above which is a small brick building. At the bottom of this pit are two horizontal, multiple-stage, motor-driven centrifugal pumps having rated capacities of 750 gal. per minute each. These pumps are driven by alternating-current, 220-volt, 3-phase motors. Motor-driven pumps were adopted for the reason that the pumping plant is isolated with reference to fuel. The flanged cast-iron pipe is provided with valves, so that either or both pumps can be operated at the same time. Check valves are placed in the suction line of each pump and in the discharge lines, and a standard relief valve is installed in front of the check valves. By the extra check valves and the relief valve in the force main, the "back lash," over a distance of 4 miles, is scarcely noticeable when the pumps are stopped.

Manual automatic starters were provided for starting the pumps and motors, which would require the presence of the operator each time the plant was put into use; however, before the plant was completed, a contract was made with the Cherryvale Electric Light & Power Company for furnishing current and labor incident to pumping. The contract stipulated the installation of remote control of the motors and pumps so that the plant could be operated from Cherryvale. This equipment was not recommended by the engineers, and they state that a great deal of trouble has been experienced with this remote-control operation. The contract provided for pumping the raw water from the river to town, and again from the filtration plant into the standpipe, under an average pumping head in each case of 200 ft. The con-

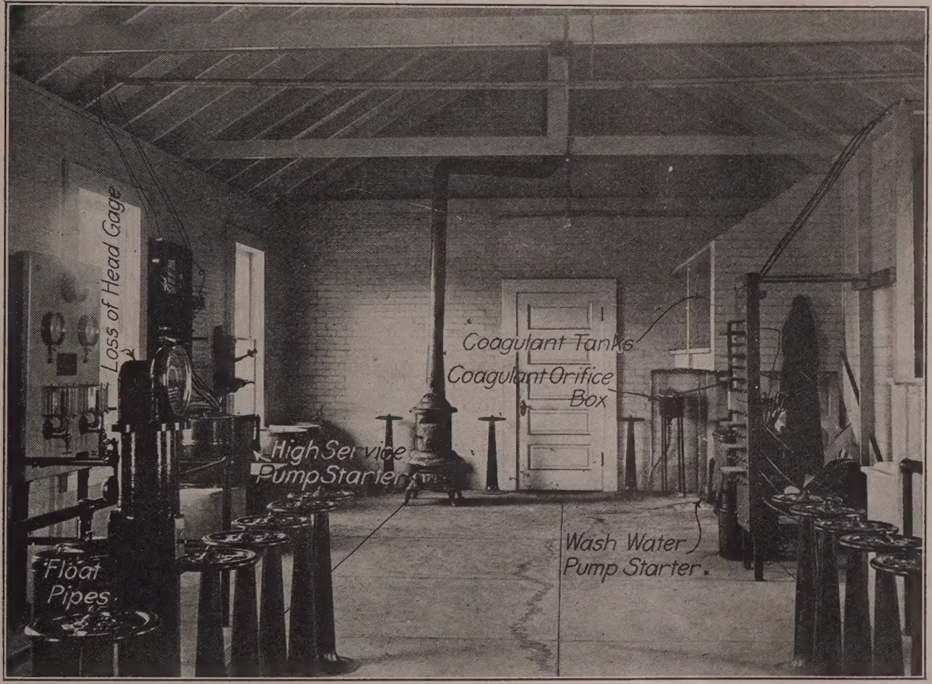


Plan and Section of Sedimentation Basin and Filters tract price is 2 cents per 1000 gal. by meter measurement for each pumping, which includes all labor, tools, small supplies and current.

Force Main and Storage Reservoir

A 12-in. force main of standard cast-iron pipe, Class A and Class B, according to the working pressure, is provided with air valves for the summits and blowoff valves for the low points.

The 1,300-000-gal. rectangular equalizing reservoir is 11 ft. deep and constructed of earth embankment, well watered and rolled, and is lined with concrete blocks 6 in. in thickness. The reservoir is 107 x 124 ft. in plan on the bottom, has banks with 1½ to 1 inner and 2 to 1 outer slopes and of 6-ft. top width. Asphalt joints care for any settlement, expansion or contraction of the blocks. Incoming water is delivered through a riser discharging 6 in. below the high-water line on the opposite side from the outlet, which is a riser, 3 ft. 4 in. below the surface. There is also a valve at the floor level making all the storage available. An overflow and drain, toward which the surface of the floor slopes, are provided.



Operating Floor of the Mechanical Filtration Plant

An 11,000-volt transmission line carrying three No. 8 wires on 35-ft. cedar poles with treated butts was built from town to the river. The poles are spaced 100 ft. apart. Standard cross-arms, insulator pins and insulators are used in this work, and all hardware is galvanized. Step-down transformers were placed at the river end and lightning arresters are provided at regular intervals. A metallic telephone circuit was placed on the poles of the transmission line.

Owing to contracts being entered for furnishing current, the power house was not constructed, but in lieu the filter house was enlarged and motor-driven, centrifugal pumps were purchased and installed.

Filtration Plant

The 5,600,000-gal. filtration plant consists of two 65,000-gal. sedimentation basins, a 50,000-gal. circular clear well separate from the other structures, and four concrete gravity filters covered by a brick superstructure, which extends over the machinery room situated between the basins and filters.

No unusual features are incorporated in the sedimentation basins, each of which is 29 ft. long by 18 ft. 9 in. wide and 12 ft. deep. The reinforced concrete battered walls are 16 in. wide at the bottom and 9 and 12 in. wide at the top. Originally water entered an inlet chamber at the bottom through a butterfly valve, but there was difficulty in operating it and it has been removed, regulation now being effected by a hand-operated gate valve. One around-the-end and under baffle prevents streaming of the water straight across from inlet to outlet pipe, the latter being located 7 ft. above the floor and passing on this elevation to the filters through the machinery room to the pipe gallery between the filters.

The clear well is 30 ft. in diameter, 18 ft. deep and is constructed of brick laid in cement mortar. It is covered with a shingle roof, although the original designs called for a concrete covering.

When operating at 125,000,000 gal. per acre daily the four filters have a capacity of 1,400,000-gal. each, but the plant was designed on the basis of 100,000,000 gal. per acre daily, and to operate at this rate for a short period only each day to care for the present population of 6000. The intermittent operation was intended to permit the plant to be cared for by one man and to provide capacity for future growth. Intermittent running of filters was seriously considered, but the engineers report the results have been satisfactory.

Each filter tank is 10 ft. wide by 13 ft. 3 in. long and 8½ ft deep to the top of the concrete cover outside of the building. A concrete gutter, 9 in. wide across the inner ends of the filters, formed by a 6-in. wall in which the two cast-iron gutters are set, reduces the sand-line dimensions to 10 x 12 ft.

The wash-water troughs are spaced on 5-ft. centers, making the horizontal travel of dirty water about 2 ft. Washing takes place at the rate of 12 in. vertical rise per minute, although the gutters are of sufficient size to carry off twice this amount. The weir edge is 12 in. above the sand surface and water is ordinarily carried 2 ft. above the weirs.

A standard strainer system of the New York Continental Jewell Filtration Company consists of 1½-in. galvanized iron laterals tapped into the side of a 6-in. header on five 15/16-in. centers. The combined air and wash-water strainer heads are screwed into the laterals at 5¾-in. intervals.

Red Wing sand, 2 ft. deep and having an effective size of 0.38 mm and a uniformity coefficient of 2.1, is supported by two 5-in. layers of gravel, ¼ to ¾ in. and ⅛ to ¼ in. in size. A pipe gallery 10 ft. wide and depressed 3½ ft. below the filter-floor level has the usual complement of influent, effluent, air, wash, and drain pipes. For ease of operation and neat appearance the hand-operated valves are all located on a line 18 in. from the filter wall. A Simplex rate controller regulates the effluent and loss of head gages indicate by electric alarm the time of washing when the maximum head of 9 ft., 4 ft. of which is negative, has been reached.

Mechanical Equipment

A Roots blower, driven by a General Electric motor, has a rated capacity of 500 cu. ft. per minute working against 3 to 5-lb. pressure. A Worthington motor-driven centrifugal pump furnishes the wash water. These machines and two multiple-stage, motor-driven centrifugal high-service pumps are located below the operating floor at the level of the sedimentation basin and pipe gallery floors. They are started and stopped by auto starters on the floor above.

The high service pumps have rated capacities of 500 to 750 gal. respectively and deliver into the distribution system and standpipe. Either filtered or raw water can be pumped, or raw water may be delivered directly into the mains from the pumps at the river, cutting out the filtration plant entirely.

On a marble board on the main floor are observation glasses for raw and filtered water, gage for the pressure in city mains, an air gage and an eight-day clock.

Aluminum-sulphate solutions are prepared in wooden tanks, located at the basin end of the main operating room, and fed by gravity by an orifice box through a 1-in. lead pipe inclosed in a 2-in. wrought-iron pipe into the raw water entering the sedimentation basin.

Guarantees for the effluent called for 98 per cent reduction in bacteria from 3500 bacteria or more per cubic centimeter in the raw water. The average number was to be 75 or less, when less than 3500 were found in the raw water. Wash water was not to exceed 5 per cent of that filtered. Samples taken on July 8, 1912, by Mr. W. C. Hoad, engineer of the Kansas State Board of Health, gave 6000 in the raw and 20 and 80 in the effluent for samples taken in the morning. At 2 p. m. the raw water showed 3000 and the effluent 30 bacteria per cubic centimeter.

The New York Continental Jewell Filtration Company had the general contract for the filter plant and sublet the concrete work to the Texas Building Company of Dallas, Texas. The pipe line, river pumping station and intake were built by Mr. F. R. Stone, of Lima, Ohio. Worley & Black, of Kansas City, were the consulting engineers.

A State Highway System aggregating 7200 miles of county roads so designated as to form interconnecting routes has been submitted for approval to the various county boards by the state highway engineer of Minnesota. About $3,500,000 a year will be expended on these roads, if the plan receives the endorsement of the counties.

Comparative Economy of Producer Gas and Steam for Pumping Stations

Unit Costs Derived from Records Covering Five Years' Operation at Two Plants

Little has been printed as to the comparative economy of producer-gas motive power for such purposes as have until fairly recently relied almost exclusively on steam power. Pumping stations are included in this category. An opportunity to compare the two types under similar conditions has been afforded by the records of the last five years at the producer-gas plant of the Delaware Water Company and the steam plant of the Octoraro Water Company, both near Philadelphia. In a paper read before the Engineers' Club of Philadelphia, Mr. J. E. Gibson, principal assistant engineer of the American Pipe & Construction Company, describes each plant, analyzes the operating and fixed charges, and derives unit figures. An abstract follows.

PRODUCER-GAS PLANT

The Delaware Water Company supplies water to the Philadelphia, Baltimore & Washington Railroad at its new shops and yards at Edge Moor and other points as far south as Newark, Del. Its pumping station is located at the head of tidewater on the Christiana Creek. The water flows from an impounding reservoir through an intake chamber, where coagulant is fed, thence through a 16-in. main to a 500,000-gal. sedimentation basin; from here it flows to the main suction well, where additional coagulant is added when found necessary. The pumps lift the water from the suction well and discharge it through mechanical pressure filters to the standpipe and storage reservoirs of the railroad company.

The building for the plant is a 44 x 130-ft. brick structure. Immediately to the rear of the producer room, at the elevation of the second floor, is located the coal storage bin. Coal is hauled from the railroad by wagons, which drive upon the roof and dump their loads through coal holes into the bin. Industrial tracks are laid in the bays of the bin on a slightly descending grade to the producer-room charging floor, thus dispensing with any form of elevator. The ashes are taken from the producer at the lower floor and wheeled to the ash bin.

As installed, the gas-producer plant consists of two complete units. Each unit is equipped with a full set of manometers and a positive type of pressure blower for blowing up fires. This blower is belt-driven from a small water motor, or, in case of insufficient water pressure, it can be operated by a hand crank attached to the extended shaft of the motor. The producers are of the standard suction type and rated at 110 hp. The gas passes from the purifiers through a 16-in. main into the engine room, where the branches are taken off to supply the engines, the far end of the main being provided with an opening to the atmosphere. In starting the plant the purge valves at the producers are closed and gas is blown through the gas main and out of this bleeder until all of the air is displaced by gas.

ENGINES AND PUMPS

There are two three-cylinder, single-acting, vertical Westinghouse gas engines, the cylinders being 13 in. in diameter and having a 12-in. stroke. Each engine is rated at 89 brake hp when operating at 290 r.p.m. The engines as installed are actually operated at 265 r.p.m. with a proportionate loss of power.

Each engine has its crank shaft direct-connected to the pinion shaft of a single-acting, triplex Deane pump with a 13-in. cylinder and 15-in. stroke. Each pump, when running at 44.1 r.p.m., has a capacity of 1,640,000 gal. per twenty-four hours. The pumps are fitted with large suction and discharge air chambers, relief valves and starting valves.

AUXILIARIES

Each pump has an independent suction pipe to the suction well, and discharges through a 16-in. connection to the 16-in. main discharge pipe. As the discharge takes place at times through a main 15 miles long, a large steel air chamber has been installed at the back end of the discharge main. This air chamber is 60 in. in diameter by 12 ft. high and is charged with air from the small air compressors used for starting the engines.

TABLE 1.—OPERATING CHARGES FOR THE LAST FIVE YEARS

	1908		1909		1910		1911		1912	
	Plant		Plant		Plant		Plant		Plant	
Item	Gas	Steam	Gas	Steam	Gas	Steam	Gas	Steam	Gas	Steam
Fuel	$609.22	$3,497.78	$641.51	$3,953.50	$1,173.58	$4,098.81	$1,474.40	$4,167.30	$1,796.35	$4,418.07
Oil, waste and packing	180.62	182.38	195.58	168.90	333.33	128.93	227.57	201.88	200.64	202.70
Building and machinery repairs	100.64	103.83	280.07	14.00	418.73	245.97	251.06	542.87	416.19	603.83
Pumping station wages	1,501.67	2,529.60	1,853.06	2,412.15	2,276.03	2,309.88	2,518.27	2,180.00	2,507.89	2,382.82
Miscell. expenses	75.09	192.59	133.75	107.09	143.18	81.11	183.90	146.03	274.81	197.30
Total per annum	$2,367.26	$6,506.18	$3,103.97	$6,655.64	$4,344.85	$6,864.80	$4,655.20	$7,238.81	$5,195.88	$7,804.72

The four filters are of the pressure mechanical type, 8 ft. in diameter by 25 ft. long, nominally rated at 500,000 gal. each. The discharge main is a compound pipe composed of two sections, the first 2.9 miles being a 12 and a 16-in. pipe and the remaining 12.1 miles a single 20-in. pipe. All water pumped is measured by a Simplex Venturi meter.

For the first year or so only one pump was operated, and for only a portion of the day, but now the consumption has reached that point where it is found advisable to operate one pump continuously and the second pump several hours each day. Accurate daily records are kept of all operating conditions, such as coal consumed, water pumped, oil used, amount of water flowing over the dam, etc.

The cost of the plant proper was as follows: Land, $5,000; building, $33,750; gas-producer plant, $13,000; pump, $7,250; piping and other auxiliaries, $4,500—total, $63,500. This gives unit costs of $392 per brake horsepower, or $1,925 per million-gallon capacity per twenty-four-hour day. These figures are exclusive of the cost of the filters, which was $13,750.

A good grade of pea coal is used, costing $5.10 per long ton, it being found that it does not pay to purchase anything but the best grade of white-ash non-clinkering coal, which must also be of a uniform grade so far as size is concerned.

STEAM PLANT

The steam station of the Octoraro Water Company is located about 3 miles south of Quarryville on the west branch of Octoraro Creek. The stream is generally very clear and free from suspended matter. A masonry intake dam across the stream forms a small pool and diverts the water to a suction well.

This plant is housed in a stone building 50 x 87 ft. The coal bin is located at the end of the boiler room and is connected therewith by a covered passage. Coal is shoveled into the bin through openings in the side walls of the building, the roadway around the coal bin being properly elevated to eliminate lifting of the coal in shoveling it.

The boiler plant consists of three horizontal-return tubular boilers 60 in. in diameter and 18 ft. long, each boiler having 1020 sq. ft. of heating surface. They were designed for a working steam pressure of 140 lb., and are connected to an 108-ft. stack.

ENGINES AND PUMPS

There are two horizontal cross-compound condensing Wetherill Corliss engines with 30-in. stroke and cylinder diameters of 18 and 32 in. They drive two horizontal, double-acting inside-packed plunger pumps, with plungers of 10-in. diameter and 30-in. stroke, designed for a working water pressure of 150 lb. per inch. The engines were designed to run at from 55 to 60 r.p.m. and were rated at 3,000,000-gal. capacity when running at the lower speed. On account of the high piston speed—300 ft. at 60 r.p.m.—the valve area of the pumps was made 173 per cent of the plunger area, and large suction and discharge air chambers were provided.

TABLE 2.—COMBINED FIXED AND OPERATING CHARGES.

Year	Gas plant	Steam plant
1908	$10,658.26	$17,978.18
1909	11,394.97	18,127.64
1910	12,635.85	18,336.80
1911	12,746.20	18,710.81
1912	13,486.88	19,276.72

TABLE 3.—COST OF PUMPING 1,000,000 GAL. 100 FT. HIGH

	1908		1909		1910		1911		1912	
FIXED CHARGES	Gas	Steam	Gas	Steam	Gas	Steam	Gas	Steam	Gas	Steam
Management	$0.995	$0.491	$0.589	$0.482	$0.318	$0.415	$0.301	$0.407	$0.293	$0.376
Superintendence	4.590	2.265	2.715	2.215	1.465	1.908	1.381	1.875	1.345	1.741
Depreciation	8.440	4.895	5.000	4.790	2.695	4.120	2.552	4.050	2.480	3.755
Sinking fund	5.200	3.180	3.080	3.120	1.658	2.685	1.569	2.645	1.522	2.498
Interest	20.400	15.970	12.080	15.620	6.500	13.440	6.150	13.230	5.980	12.270
Insurance	.379	.615	.224	.602	.121	.519	.114	.509	.111	.473
Taxes	1.313	.803	.787	.788	.418	.693	.396	.666	.400	.618
Total	$41.317	$28.219	$24.475	$27.617	$13.175	$23.780	$12.463	$23.382	$12.131	$21.731
OPERATING CHARGES										
Fuel	2.615	2.410	1.441	2.698	1.291	2.425	1.505	2.510	1.860	2.305
Oil, waste and packing	0.775	.126	.439	.115	.366	.076	.232	.126	.208	.106
Pumping station wages	7.490	6.210	5.470	5.825	3.615	4.790	3.787	4.450	3.670	4.520
Machinery repairs and building	.432	.072	.631	.0095	.461	.146	.256	.327	.431	.315
Miscellaneous expenses	.322	.133	.300	.0735	.157	.048	.188	.088	.285	.103
Total	$11.634	$8.951	$8.281	$8.721	$5.890	$7.485	$5.968	$7.501	$6.454	$7.349
Grand total	$52.951	$37.170	$32.756	$36.338	$19.065	$31.265	$18.431	$30.883	$18.585	$29.080

Average cost of pumping 1,000,000 gal. 100 ft. high, gas = $28.36
Average cost of pumping 1,000,000 gal. 100 ft. high, steam = $32.95.

Each engine is equipped with a surface condenser located in the suction pipe to the main pumps, and a 7 x 12 x 15-in. independent horizontal single-cylinder, double-acting air pump. Two 7½ x 5 x 6-in. feed pumps supply water to the boilers. The exhaust steam of all auxiliaries is piped to a 500-hp Cochrane heater. In all details the steam piping is complete, special care having been taken to prevent accidents.

The engines have independent suction pipes to the suction well located just outside of the engine room. No foot or check valves are used, but each air pump is connected with its respective suction air chamber of the main pump so that suction pipe, condenser shell and suction chambers are entirely exhausted of air and full of water before the engine is started. The discharge main is 16 in. in diameter and 2.21 miles long. All water pumped is measured by a 16-in. Simplex Venturi meter. Usually one pump and two boilers are in use. The number of hours the plant is operated per day varies with the changing consumption and the amount of water pumped by the water-power stations. This latter amount depends entirely upon the flow of the creek. Accurate daily records are kept of all operating conditions as in the Delaware plant.

The cost of the plant was as follows: Land, $5,000; building, $32,875; complete mechanical plant, $39,850; total, $77,725. This gives unit costs of $190 per brake horsepower, or $1,210 per million-gallon capacity per twenty-four-hour day.

The best grade of bituminous coal from the South Fork region is used, costing $4.40 per long ton, delivered. This coal is high in carbon, low in volatile matter and is one of the best steaming coals mined in Pennsylvania.

Daily Records

As before stated, complete daily records of operating conditions were kept at the pumping stations. These included fuel consumed, daily pumpage, total pumping head, number of hours in operation, steam pressures, vacuum, revolutions of engines, feed water pumped to boilers, oil waste and packing used, supplies received and operating force employed.

The operating expenses may be divided into five general headings: (1) Fuel; (2) oil, waste and packing; (3) pumping-station wages; (4) building and machinery repairs, and (5) miscellaneous expenses. These expenses are easily obtained from the companies' books, but there are other expenses, such as management, superintendence, depreciation, sinking fund for retiring the bonded debt, interest, insurance and taxes. The overhead and fixed charges cannot be accurately determined, as the accounts include pipe lines, reservoirs, standpipes and other pumping stations, and therefore they have been merely estimated.

Fixed Charges

Under the heading of management is included the legal organization of the company consisting of a president, a secretary-treasurer and a board of three directors. The president and treasurer each receive $1,000 per year for their services, and the directors each receive $10 per board meeting. Assuming that the board meets once each month this charge would amount to $360 per year, or a total of $2,360 for management. This amount covers the entire system. The amount chargeable to mechanical plant is necessarily very small but is arbitrarily taken at $200 per year for each company.

Under superintendence is included the salaries of the superintendent and his office assistants, stationery, postage, telegraph, telephone, office rent, livery and other incidental expenses. These items are figured as follows: Superintendent's salary, $2,500; bookkeeper and clerk, $1,200; stenographer, $500; office rent, including heat, light and water, $300; postage, $100; telephone and telegraph, $170; stationery, $250; livery and miscellaneous expenses, $500; total, $5,520, of which amount one-sixth, or $920 per year, has been charged to the mechanical plant.

In depreciation is considered only the mechanical plant and its housing. For the steam plant average lives of 20 years for the mechanical plant and 35 years for the building are figured. For the gas-producer plant only 15 years are allowed for the mechanical plant and 35 years for the building. Setting aside at the end of each year sums which at 4 per cent compound interest will at the expiration of the life of each plant amount to its first cost, the sums for the Delaware plant are $1,236 for the mechanical plant, exclusive of filters, and $458 for the building, or a total of $1,694. Similar figures for the Octoraro plant are $1,340 for the mechanical plant and $447 for the building, or a total of $1,787.

The sinking fund, figured upon a 4 per cent basis and a 30-year life of bonds, amounts to $1,043 for the Delaware plant and $1,297 for the Octoraro plant. The annual interest charge, taken at 7 per cent, amounts to $4,095 for the Delaware plant and $6,491 for the Octoraro plant.

Both plants are fully equipped with fire-fighting apparatus and thereby receive the benefit of the lowest insurance rates for isolated plants. This amounts to $66 per year for the Delaware plant and $90 per year for the Octoraro plant. The boiler and liability insurance is taken at $160 per year for the Octoraro plant. The Delaware plant has no boiler plant and therefore only liability insurance is carried, costing $10 per year for $10,000 insurance. The total insurance charges are therefore $76 for the Delaware plant and $250 for the Octoraro plant.

Taxes amount to $263 per year for the Delaware plant and $327 for the Octoraro plant. Summing up all of these fixed charges, they are found to amount to $8,291 per year for the Delaware plant and $11,472 for the Octoraro plant.

Explanation of Tables

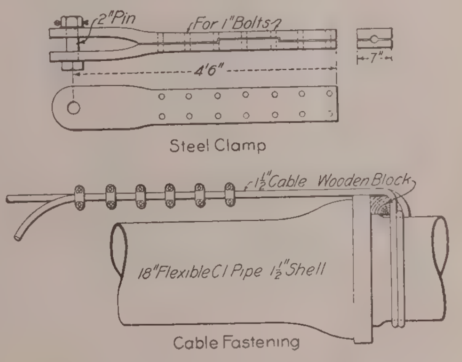
Table 1 gives the operating charges at each plant for each of the last five years. Table 2 includes the fixed and overhead charges summed up in the previous paragraph. Table 3 gives the comparative costs of pumping 1,000,000 gal. of water 100 ft. high by the two systems, taking into account the heads against which the water is pumped at the two plants. The figures for all of the fixed-charge items, and for the pumping-station wages, were obtained by dividing the annual cost for the item by the actual number of million gallons pumped for the year, as these charges were independent of the pumping head. The remaining items were obtained by dividing the annual cost by the equivalent million gallons pumped 100 ft. high per year.

The average costs for pumping 1,000,000 gal. 100 ft. high for the five-year period are seen to be $28.36 for the gas plant and $32.95 for the steam plant. This is equivalent to $56.80 and $68.50 respectively per horsepower for twenty-four-hour power delivered to the customer, or, stated another way, it is equivalent to 0.88 and 1.05 cents per kilowatt-hour for the steam and gas plants respectively.

In conclusion Mr. Gibson believes that while the local conditions, nature and cost of fuel available, etc., must enter into every discussion as to the kind of power to be adopted for a proposed plant, the use of gas has a much wider field than has heretofore been accorded it.

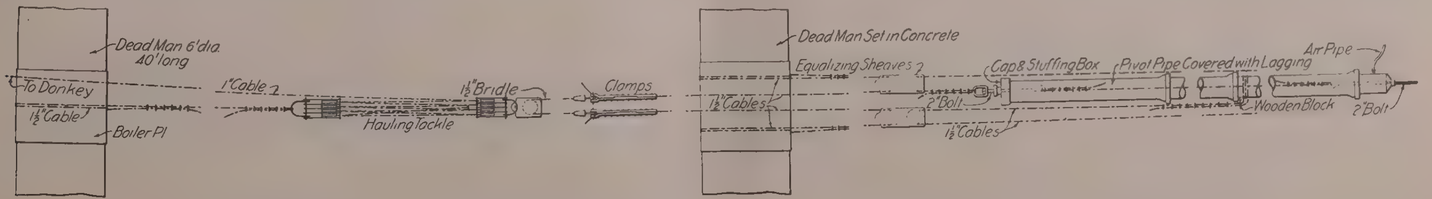
Hauling Submerged Water Main with Steam Winch

Since the water-supply system of Vancouver, B. C., was first inaugurated a total of sixteen 12 and 18-in. submerged mains have been laid across Burrard Inlet to bring water to the city from the mountainous slopes of the opposite shore. All of these mains have been drawn under the water after the pipe had been assembled, in lengths varying from 1000 to 1300 ft., by steel cables arranged in various ways and operated by steam or horse power There have been many unforeseen elements, however, entering into the problem of hauling the mains which often gave serious trouble—tackle has been broken, 1½-in. cables snapped, or even lengths of the pipe cracked in landing, so that expensive repairs by divers were necessary.



Clamp and Cable Fastening

The most recent extension to the water-supply system called for an 18-in. main across the Second Narrows, and this was put in place on July 25. Steps were taken to profit by all earlier experience, and careful provision was made for each element that has heretofore interfered with the successful completion of the work. As a result the 1000-ft. length of the new main which lies below low-water line was



Arrangement of Lines, Tackles, and Deadmen and Details of Cable Connection with Pipe to Be Hauled

successfully drawn from shore to shore in just four hours' actual hauling time.

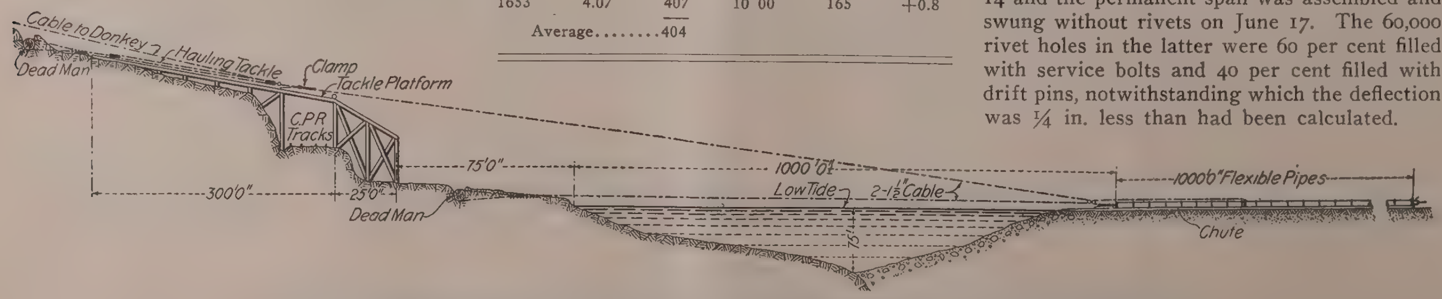
The pipe was assembled on the north shore and drawn across by a 30-hp logging engine located on the south side some 400 ft. back from the high-tide line and about 100 ft. above water level. Between the engine and the water a platform was constructed to keep the tackle free and carry it over the tracks of the Canadian Pacific Railway. On the north shore a chute was built over the tidal flat to low water line, and of sufficient length to allow the full length of pipe to be assembled upon it. Each length of the pipe was first tested at the place of manufacture to a pressure of 500 lb. per square inch and, after it was delivered on the ground, to a pressure of 300 lb. per square inch and was then placed in the chute, 112 lengths in all being required. After all the pipe was connected up in the chute a final pressure test of 210 lb. per square inch was given the whole line. Under the end of each length a wooden shoe was placed to facilitate its movement along the chute and provide access for the calking of the lead joints. The pipe is provided with ball-and-socket joints, which give the flexibility necessary for adjusting itself to the contour of the ground below water, thus preventing any suspended sections. The maximum angle of deflection for any two adjacent lengths is 19 deg. Each length weighs about 3500 lb. and has an effective length of 9 ft.

The arrangement of tackle for hauling the main is shown in the accompanying drawing. It will be noted that the cable attaches to the pipe at four points and that the stress at these points is rendered the same by the equalizing sheaves at the head end. The arrangement of the hauling tackle and platform lengths was such that the pipe could be moved 125 ft. for each new grip of the clamps at the end of the bridle. During the hauling these clamps were moved eight times, thirty minutes being sufficient in each case for advancing the pipe 125 ft. and renewing the grip of the clamp.

Both ends of the pipe line were plugged, and a stuffing box was used for the forward bolt to pass through, but to still further guard against entrance of water, which might get in through leaks at joints, an air hose was tapped into the rear plug, and an air pressure of about 40 lb. maintained during hauling. Keeping the pipe free of air meant lessening the necessary pull by 57 tons, but in order to provide for contingencies, the tackle was made sufficiently strong for moving the pipe when full of water. It was calculated that the hauling weight would be apportioned as shown in the table:

Distribution of Weight

	Tons
Total weight of pipe (filled with water and joints leaded)	270
Water displacement	85
Effective weight of pipe line	185
Effective weight of cables and fastenings	5
	190
Estimated coefficient of friction	0.7
Total pull required	133



Section across River, Showing General Scheme of Hauling the Pipe to Place at Vancouver, B. C.

The work was performed under the personal supervision of Mr. H. M. Burwell, of Vancouver, B. C.

Automatic Chemical Feeder

An automatic type of chemical feeder has recently been tested at the hydraulic laboratories of the University of Illinois by the patentee, Mr. Ralph Hilscher, an engineer with the Illinois State Water Survey. The apparatus works in conjunction with a Venturi meter and depends for its action directly on the decreased static head at the restricted section.

Referring to the sketch, the device consists of a box divided into two compartments by a wall which extends from the bottom to within a short distance of the top. At the top of this wall is pivoted a horizontal arm, from which are suspended two floats of equal dimensions, one in each compartment, and at equal distances from the pivot. The arm in compartment B extends beyond the float and connects with a balanced valve on the end of a feed pipe, which supplies chemical from a supply tank. The valve is so made that when the float in B falls below the float in A the downward movement of the arm will cause the valve to open and admit chemical solution to compartment B.

Connecting compartment B with the reduced section of a Venturi tube is a pipe in which there is an adjustable valve. Another pipe connects A with the full section of the Venturi tube. The Venturi tube is inserted in the pipe to which it is desired to feed the chemical.

When a flow of water occurs through the Venturi tube unequal pressures at the full and reduced sections will tend to make the levels in A and B different, that in B being lower. This difference in pressure, represented by *h*, is proportional to the square of the rate of flow through the Venturi tube and, if utilized to force chemical solution through an orifice, will produce a flow through that orifice directly proportional to the flow in the main. The adjustable valve acts as an orifice in this device and the desired effective head on it is established by building up the level in B equal to that in A. As already explained, these two levels are kept the same by the float arrangement.

Tests of Automatic Chemical Feeder

Gallons treated.	Gallons solution applied	Ratio of Col. 2 to 1	Time of run, in minutes and seconds	Gallons per minute treated	Per cent by which ratio departs from average
639	2.98	214	5 39	113	+6.2
726	3.49	208	6 30	112	+3.2
682	3.58	190	5 12	131	—5.8
1495	8.03	186	10 11	146	—7.7
1382	6.59	210	17 10	80	+4.3
Average		202			
1620	5.85	277	9 20	174	+1.8
1014	3.80	267	18 55	54	—1.8
Average		272			
1294	2.98	434	19 30	66	—0.2
1680	3.94	426	10 00	168	—2.1
1355	3.04	445	14 30	93	+2.3
Average		435			
1365	3.55	384	13 30	101	—4.8
1506	3.58	420	26 00	58	+4.0
1653	4.07	407	10 00	165	+0.8
Average		404			

Referring to the test sheet, the figures are for four different tests, each with a different size of opening of the adjustable valve. The first column contains the quantities of water treated, measured in a large tank at the end of each run. Column 2 contains the corresponding quantities of solution fed by the machine, determined by measuring the drop in the supply tank. Column 3 gives ratios of column 2 to 1, and these figures should all be the same theoretically for a given size of orifice. The ratios are averaged for each test, and in the sixth column are given the per cents by which the various ratios depart from the average. By reference to the fifth column it will be seen that rates at which water was treated varied by about 300 per cent.

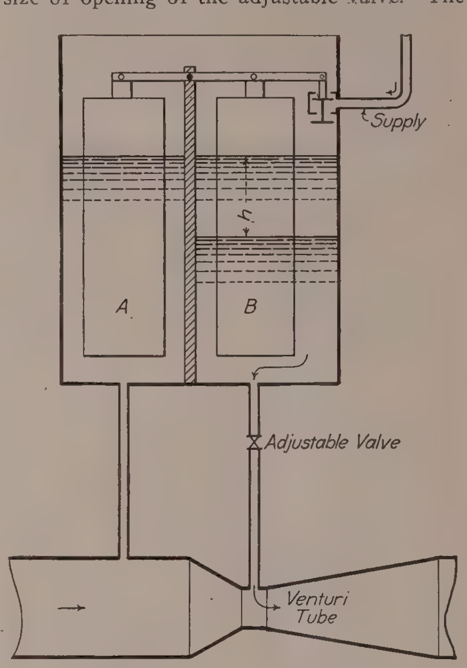


Diagram of Chemical Feeder

Erecting the Paskey Bridge over the lower Ganges at flood stage involves some unusual work, which has so far been safely executed, according to "Indian Engineering." The bridge has several long spans, which, over the deep channel, are to be erected on a movable 870-ton falsework span. The shallow water spans are erected on ordinary wooden falsework. The last piece of steel for the 1200-ton end span was received May 20 and the last piece of the falsework span May 29. The flood season was approaching and the erection of both spans was immediately commenced. Unprecedented rains produced a sudden flood, which commenced on June 15, and on June 18 submerged the wooden falsework. The falsework span was riveted up and swung June 14 and the permanent span was assembled and swung without rivets on June 17. The 60,000 rivet holes in the latter were 60 per cent filled with service bolts and 40 per cent filled with drift pins, notwithstanding which the deflection was ¼ in. less than had been calculated.

Construction of Arrowrock Dam

Cement Is Conveyed to Mixer by Compressed-Air Pipe Line and Concrete Placed by Hoppers and Trough Suspended from Cableway

The Arrowrock dam, the principal engineering feature of the Boise project of the U. S. Reclamation Service in Idaho, is famous for its great height—351 ft. above foundations—and has been described in several articles in the Engineering Record. Concreting has been in active progress for some time past and the following notes and pictures, taken from an article by Mr. M. G. Doll in "Mine and Quarry," indicate the present condition of the highest masonry dam in the world.

The dam is being constructed to form a reservoir for conserving the water of the Boise River, which will be used, together with water from the Deer Flat reservoir, as a late season water supply for irrigating about 240,000 acres of land in the Boise Valley. When the dam is completed it will form the outlet for a reservoir with a storage capacity of 230,000 acre-ft.

The water from the Arrowrock reservoir will be discharged into the Boise River, in which it will continue for about 15 miles to a point 8 miles above the city of Boise, where it will be diverted by a dam into the New York Canal, and thence distributed by small canals and ditches over the acreage to be irrigated.

LOCATION

Several sites for the dam were available. After a thorough general investigation with Sullivan diamond drills the site at Arrowrock was chosen. Sixty holes were put down to a sufficient depth to show solid cores from bedrock 30 to 50 ft. in length. These bore holes revealed the fact that at this particular place the greatest depth to solid rock—in this case a good quality of hard granite—was about 90 ft. below the bed of the river, with an average depth of 65 to 70 ft. over most of the area. The overlying material consisted of sand, gravel and boulders. The walls of the canyon are fairly narrow, with a steep granite cliff on the north side, and a less precipitous slope covered for some distance by a cap of lava rock rising 20 to 50 ft. above the water surface on the south side.

On account of the vast amount of material necessary for the construction of so large a dam, and the long haul, the first step was to build a railroad from Barberton, where a connection is made with the Oregon Short Line Railroad to Arrowrock, a distance of 17 miles. It was completed on Nov. 9, 1911, and daily train service was started on Dec. 20, 1911, from Boise to Arrowrock. This is the only standard-gage railroad in the United States operated by the government.

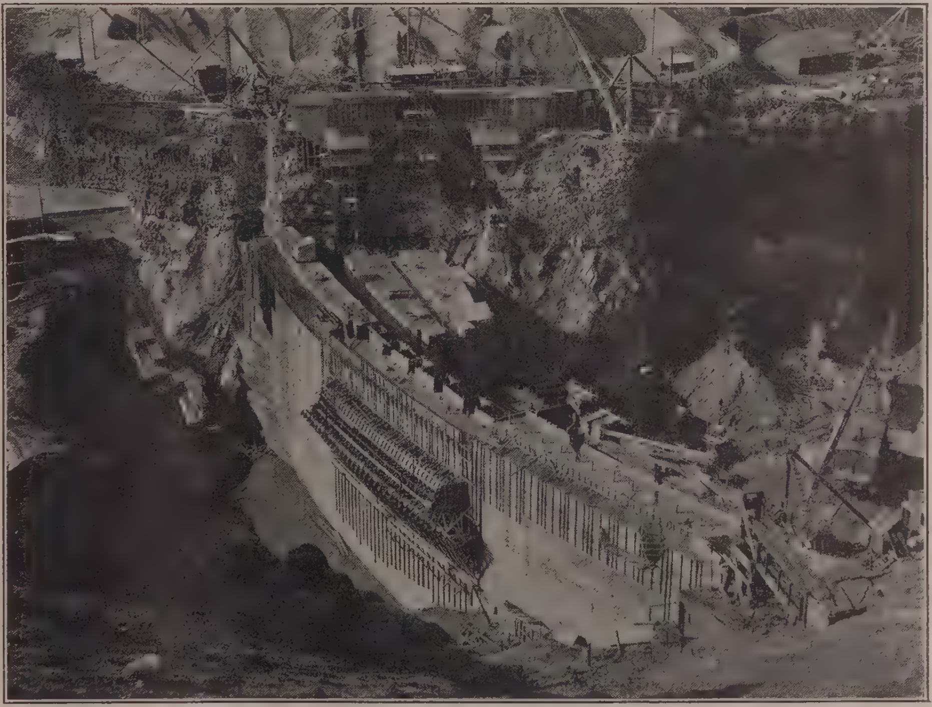
DIVERSION WORKS

During the summer of 1911 work was started on the camp and diversion works, which were to take care of the river flow during the construction period. (See Engineering Record, April 6, 1912, page 368.) The diversion works consist of an upper cofferdam, diversion tunnel and lower cofferdam. The upper cofferdam is about 200 ft. long and 35 ft. high, built of timber cribs filled in with rock, gravel, and with fine material sluiced into the crevices. A sheet-piling cutoff is used with the cribs. This cofferdam turns the flow of the river into the diversion tunnel. The lower cofferdam, which protects the workings from the water, leaving the diversion tunnel below the excavation, is about 150 ft. long and 25 ft. high. The construction is the same as that of the upper cofferdam. In order to take care of seepage, electrically driven belted centrifugal pumps of various capacities are mounted on cars 24 ft. long, that run on an inclined track with an 8-ft. gage. As the excavation progresses and the water level is reduced, these cars may be raised or lowered by means of a small hoist at the top.

The diversion tunnel is 30 ft. wide, 25 ft. high, and 500 ft. long, and was driven its entire length in very hard, solid granite, underneath the lava cap, on the south side of the river.

The entrance to the tunnel is through a carefully designed bell mouth, so as to avoid all eddy currents and cross-currents. Every effort was made to effect as smooth and symmetrical an entrance as possible to secure a maximum velocity of 30 ft. per second of the water through the tunnel. The outlet to the tunnel is also a carefully designed bell mouth so as to save head as the water passes to the river below.

The roof of the tunnel is arched, with the top 10 ft. above the springing line. The sides are vertical.



Completed First Section of Dam, with Concrete-Mixing Plant in Background

DIMENSIONS OF DAM

In design the dam is a normal, gravity section type, but the factor of safety is increased by giving it a curve in plan, with a radius of curvature of 662 ft. The length of the crest is 1060 ft. and the height 351 ft. above foundations. The dam is 16 ft. wide at the top and at the base 240 ft. It covers about an acre. The concrete in the dam will be about 530,000 cu. yd. The dam proper is being constructed of rubble concrete, containing as many boulders as can be incorporated economically and without delay to the work, or about 20 per cent of the entire mass. The concrete mixture is about 1 part sand-cement, 2½ parts sand, 5 parts gravel and 3 to 4 parts cobblestones, in which the boulders will be imbedded.

The gates and accessories will weigh about 1000 tons. Outlets will be provided at several elevations, so that it will not be necessary to operate the gates under any very great head of water at any particular time. Provision is also being made for power facilities if it should be decided to develop power at a later date.

SPILLWAY

The spillway is being constructed at the north end of the dam, and will have a carrying capacity of 40,000 sec.-ft.; this will require excavation of about 350,000 cu. yd. of solid granite, which is being removed in benches. The spoil is loaded by a steam shovel into ordinary dump cars hauled by dinkey engines. The surplus water will enter the spillway over a concrete lip about 400 ft. long, which will be built at right angles to the line of the dam, the line of the lip following the line of the ground contour. The water will fall over this lip into a concrete-lined trench, which runs parallel to the lip. It will then be carried beyond the end of the dam and allowed to cascade over the granite cliffs to Deer Creek, which will then carry it back into the river below the dam.

The design of the dam is such that water may flow over it without danger to a depth of 3 ft., so that in cases of exceptional flood, too great to be taken care of by the spillway, the upper set of outlet gates may be used to take care of an additional 15,000 sec.-ft. of flood water.

DAM CONSTRUCTION

On account of the size and great depth of the excavation necessary for the dam, it was out of the question to use sheeting and braces for holding the sides. Excavating for and constructing small sections of the dam independently was objectionable because of the slower progress, the greater expense, and the added danger of being flooded out if the work below the water level was extended over too long a period.

To overcome these difficulties it was decided to excavate a sufficient space over the river bottom to permit of the construction of a portion of the upstream face of the dam entirely across the river. This portion was to be of

Upstream View of Diverting Tunnel and Appurtenant Structures at the Dam

sufficient size to serve as a gravity section, and with the top about 20 ft. above the present high-water mark of the river it would give additional protection against floods, and also would cut off all seepage from the upstream side of the excavation during the remainder of the construction period.

In order to prevent leakage in the foundation of the dam, a line of holes was drilled, just inside the line of the upstream face, 30 to 40 ft. in the solid granite. (These holes were drilled with Sullivan Class "UF-2" (3¼-in.) drills mounted on "U-6" tripods.) These holes were grouted under pressure, but the rock was so solid that it showed no indication of taking the grout.

Drilling and Grouting Foundation

A line of holes was also drilled just downstream from the grouted holes. These were led up through the dam structure, and will be carried into a large inspection tunnel, that will run the entire length of the dam, just above normal high-water surface of the backwater. This inspection tunnel will be about 30 ft. high, and wide enough to permit the operation of grouting or drilling equipment. These open holes will be used as weep holes, and should they show any indication that the foundation requires further treatment at any place after the reservoir is filled, drilling and grouting may be carried on in the tunnel.

The large deep blast holes, both in the spillway and in the keyway of the dam, are drilled with Sullivan 3¼-in. drills, and the pop holes, necessary for breaking and blasting the larger boulders and pieces of rock before the excavator and steam shovel, are drilled by Sullivan air jet hammer drills, using hollow steel. The trimming in the keyways and spillway is also done with these tools.

The excavation of the river bottom is accomplished by a drag-line excavator with 2½ cu. yd. buckets and a 70-ft. boom, a 70-ton steam shovel with 2½ and 2-yd. dippers, two 15-ton electric cableways with spans of 1500 ft.; the height of the cableway head towers is 60 ft., and the height of the tail towers 100 ft.; the hoisting speed is 300 ft. per minute, and the traveling speed 1200 ft. per minute. The cableways are equipped with 4-yd. skips and orange-peel and clamshell buckets. The height of the cableways above the foundation of the dam is 375 ft., and they are operated by 300-hp motors.

Practically all the material from the excavation of the river bottom, which will be about 250,000 cu. yd., and the material from the spillway, about 350,000 cu. yd., will be used in the construction of the dam, as sand, gravel, boulders or crushed rock.

All the material from the river bottom is taken to a sizing plant high up on the south side of the canyon and separated into sand and different-sized boulders by being dropped over grizzlies and screens, and from the grizzlies and screens through chutes to the various storage bins, whence the material is taken as needed to the concrete-mixing plant, located lower down on the side of the canyon and above the dam. The sand and fine gravel found in portions of the bed are picked up with the orange-peel and clamshell buckets, while the boulders and rock are carried in the skips.

The granite from the spillway is sent to the sand-cement plant, located on the north side of the canyon and of a capacity of 1000 bbl. of sand-cement per twenty-four-hour day. It consists of a rock crusher, sand rolls, rotary dryer, ball mill, mixing machine and three 5 x 22-ft. tube mills.

Sand-Cement Plant

This sand-cement is made by blending ordinary Portland cement with about an equal volume of pulverized granite. The granite obtained from the spillway excavation is run through the rock crusher and sand rolls, then through the dryer and into the ball mill, where it is pulverized to pass a 20-mesh sieve. It is then mixed with the Portland cement and ground with it in the tube mills to such fineness that about 95 per cent will pass a 200-mesh sieve. The resulting product gives a mixture as strong as the original Portland cement, and is used in the construction of the dam in the same proportions as the original Portland cement would be used, thus practically cutting in half the quantity and cost of the cement necessary.

Compressed-Air Conveyor

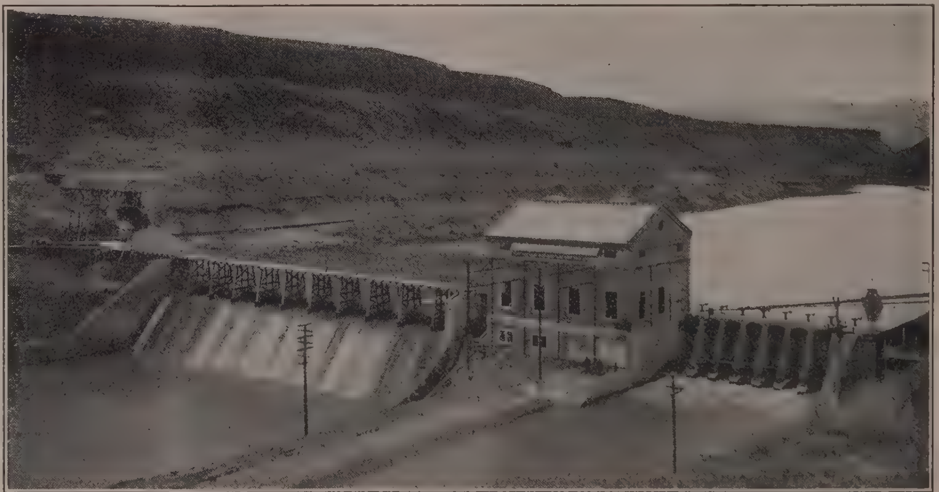
From this plant the sand-cement is carried across the river and up the side of the canyon, a total distance of about 1500 ft., to the concrete mixer by compressed air through a 4-in. air line.

To accomplish this, the sand-cement is loaded from the mill bin into a vertical hopper, connected at the bottom with the conveyor air line, through the vertical opening of a standard pipe tee. One of the horizontal openings of the tee is connected into the conveyor line. Into the opposite end of the tee is connected, by means of suitable bushings, a ¾-in. air line. A nozzle is connected to this ¾-in. pipe, inside the conveyor, pointed in the direction of the flow of the sand-cement. After the hopper is filled with sand-cement it is tightly closed and the air turned on, carrying the cement to bins in the concrete-mixing plant. At various intervals along the conveyor pipe line, and also at each turn or bend in the conveyor pipe line, a tee is inserted, and through each of these tees a ¾-in. air line is connected with a nozzle pointed in the line of the flow; these are boosters and keep the conveyor line open and the flow of sand-cement continuous.

The compressors furnishing the air for the rock drills also furnish the air for the conveyor, so that up to the present time no experiments have been conducted to determine the quantity of air or air pressure necessary to perform any unit quantity of this work, but general observation would indicate that it is an economical process, and it is certainly quick and convenient.

Concrete-Placing Apparatus

After the concrete is mixed and ready for placing in the dam it is carried and placed by two Crowe concrete-placing cableways and equipment. This apparatus consists of two hoppers and a long trough suspended from a cableway. The cableway is located in the proper position to carry the concrete from the mixer over the dam. The upper hopper transports the concrete from the mixer and dumps



Power House at Barber Junction Furnishing Energy for Construction Plant it into the lower hopper, which connects directly with the long trough. The lower end of this trough is suspended in such a manner that it can be moved through a circle, so that the concrete may be dumped at any time at any desired point in the dam. This apparatus, Mr. Doll states, is not only extremely economical in operation and speed, but it is also very much more convenient for distributing and placing concrete than other methods.

Power House

For furnishing the necessary power for lighting the camp, construction works and operating the construction equipment, a hydraulic power plant was built 3 miles above Barber Junction on the Arrowrock Railroad and started operation in May, 1912. The capacity of this plant is from 2500 to 3000 hp. The equipment consists of three alternating-current, 60-cycle, three-phase, 2300-volt generators. This power is transmitted from the station at 22,000 volts. The transmission lines to Arrowrock are in duplicate so as to insure continuous service.

The lumber necessary for the camp and construction work is cut at a sawmill, operated by the U. S. Reclamation Service, about 17 miles up the river from Arrowrock. The total output of this mill will be about 5,500,000 ft. b.m.

Construction Camp

The construction camp buildings include an office, general workshop, steam-heating plant, engine house, warehouse, store, meat market, bakery, root cellar, stable, bathhouse, laundry, hospital, isolation hospital, clubhouse, mess house for office and clerical force, general mess house, fifteen general bunk houses, and about one hundred and twenty-five family houses, cottages and tents, for use of superintendents and men with families. This makes a camp with a capacity for taking care of about 1000 working men and a total population of about 1500.

The general shops comprise a wood-working shop, machine shop and blacksmith shop, all well equipped.

The water-supply, sewage-disposal and fire-protection systems are complete and efficient, so that this little settlement is as well equipped with the machinery of civilization as a permanently located town of many times its population.

On May 31 work was well under way on the excavation for the second section of the dam, 225,000 out of a total of 250,000 cu. yd. of material having been removed from the river bed. Excavation in the spillway was 40 per cent completed, with 140,000 yd. removed.

Tor Hill Reservoir at Regina

5,000,000-Gallon Reservoir in Saskatchewan, Canada, with Reinforced-Concrete Roof Slab Resting on Structural-Steel Frame

By R. O. Wynne-Roberts, M. Inst. C. E., Consulting Engineer, Regina, Saskatchewan

Last year the city council of Regina, Saskatchewan, Canada, on the recommendation of Mr. A. J. McPherson, then city commissioner, decided to adopt a scheme, which the writer had submitted, whereby an ultimate daily supply of 10,000,000 gal. of water can be made available at an expenditure of about $2,000,000. Two 5,000,000-gal. reservoirs were included in the scheme and the first of these, Tor Hill reservoir, has been in use since April. The depth of water has been maintained at about 23 ft. for more than a month.

Tor Hill reservoir is 202 ft. in diameter, has a 25-ft. depth of water, is circular in plan, made of reinforced concrete, and is located on a hill close to the Boggy Creek waterworks, with the top water line about 120 ft. above Regina level. It is so situated that it will serve in connection with future extensions into five other watersheds of the water-collecting works.

Excavation and Footings

The excavated material, averaging 9½ ft. in depth, was of the heterogeneous character so common to glacial formations, ranging from fine sand to heavy clay. It was removed by horse-drawn wheel scrapers and deposited at convenient points, to be utilized afterward in forming an embankment around the reservoir. For this work ordinary scrapers were employed, and the quantity of material handled was about 12,500 cu. yd.

The footings were laid 1 ft. lower than the under side of the floor, except where pipe connections are located, where the thickness was made 2 ft. beneath the under side of the pipes. The footings extend for a distance of 3 ft. 8 in. under the floor from the inner face of the wall and are reinforced with ½-in. round bars laid radially and circumferentially, and also by diagonal braces laid radially, 6 in. on centers, so as to form a strong tie between the wall and the floor.

Floor and Columns

The reservoir floor is 12 in. thick, having a fall of 1 ft. to the scour pipe, which is laid to a sump hole at a depth of 2 ft. 3 in. below the floor level. The floor was laid in two layers, each 6 in. thick, and between them were laid ½-in. mild steel bars, 6 in. on centers in both directions, tied together at every fifth intersection in one way and at every intersection in the other. The top surface of the concrete was worked to a fine close texture.

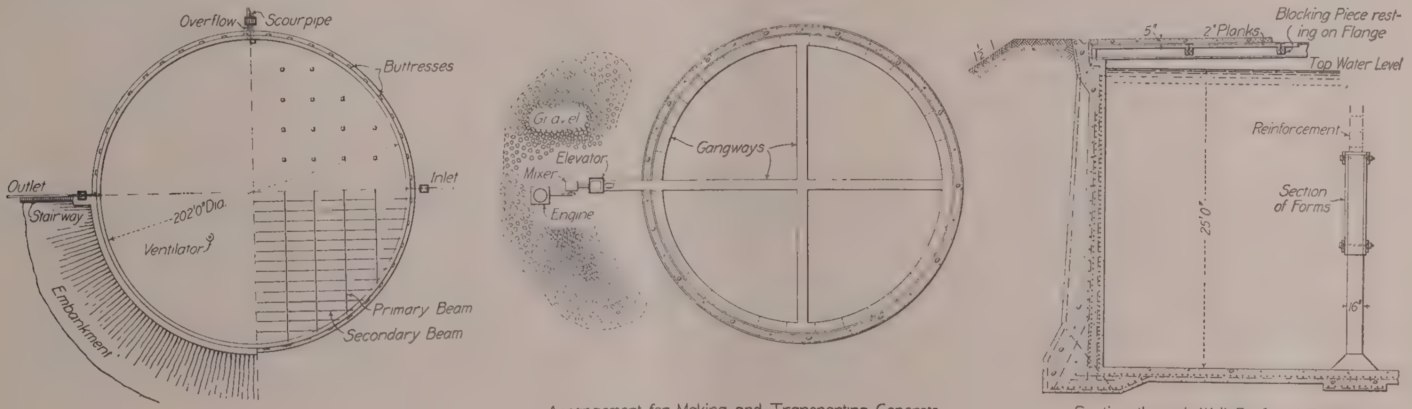
There are sixty-nine reinforced-concrete columns, each 16 x 16 in., supported on truncated pyramidal bases 4 ft. square and 1 ft. 3 in. high, which, with the 6 in. sub-base, forms an integral part of the floor. The sub-base was reinforced with ½-in. bars laid at 6-in. centers in cross directions.

The columns are reinforced with four ¾-in. round bars tied by 1 x 1-16-in. hoop-iron links at 10-in. intervals. Where the bars join the base they are inserted into wrought-iron tube sleeves ¼ in. larger in diameter and grouted with liquid cement. After the bases had set these rods kept the forms from rising when being filled with wet concrete.

Forms for the columns were made in three sections, built of 2-in. planks with 4 x 4 in. cross-pieces placed 3 ft. on centers and held together by ⅝-in. bolts. Each section was numbered so that three forms made a complete column. Sufficient forms for twenty columns were made, and they were therefore used at least three times each. These forms were assembled on the ground, hoisted up and lowered over the rods by means of a light ginpole on a monkey derrick built on skids. The derrick, which was moved from column to column by the men, was of a light construction and made of 2 x 8-in. boards. The columns were braced by 1-in. boards tied to the wall forms and were plumbed to assure the perpendicularity of the lower forms; the other forms were held in place by two bolts holding the second and third sections down to the one already filled in. One section about 9 ft. high was filled each day.

Circular Wall

At the floor level the wall is 57 in. thick, while 7 ft. above the floor a steep batter on the outside reduces it to 18 in., and from this point it tapers to 14 in. at the top water line. It then corbels out to allow a base for the roof beams and for a rain-water gutter. In the original design the wall was to be 9 in. thick at the top and 14 in. at a height of 5 ft. above the floor, with three external reinforced-concrete rings placed at points of equal pressure, to provide extra strength, as the work would be carried out under somewhat unusual conditions; but owing to the delays already mentioned it was deemed expedient



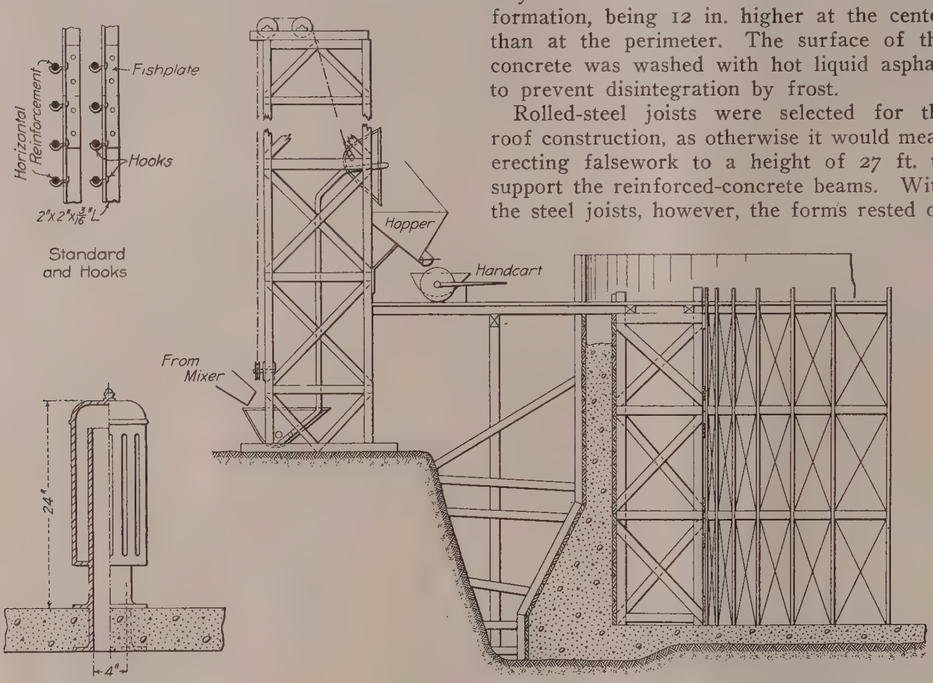
Plan

Arrangement for Making and Transporting Concrete

Section through Wall, Roof and Bottom

Plan and Section of Tor Hill Reservoir and Arrangement of Plant for Placing Concrete to alter the design by eliminating the rings and thickening the walls by an equivalent volume of concrete and steel, so as to simplify the construction and thus expedite the work. The inside face of the wall is vertical.

The horizontal reinforcement in the wall was designed to take up the tensional stresses proportional to the varying depths of water. At the floor level there are two 1⅜-in. round bars at 3-in. centers curved to a template to fit the curvature of the wall. At the top 1-in. bars are spaced 4½ in. on centers. These bars are held in place by 2 x 2 x ¼-in. steel angle standards, in which holes were drilled at prescribed distances, and ¼-in. steel hooks inserted to clip the rods. Such standards are 3 ft. 6½ in. apart along the perimeter of the reservoir, and are fixed so that there are 5 in. and 3 in. of concrete between the horizontal steel reinforcement and the water face at the bottom and top respectively. This method of placing and fixing the horizontal bars resulted in a firm and satisfactory framework, undisturbed by the men placing the concrete.



Standard and Hooks

Ventilator

Staging for Transportation of Concrete

Ventilator Detail and Staging and Forms for Concreting

The vertical reinforcement consists of ½-in. bars at 8½-in. centers tied to the horizontals by black wire at every fifth intersection vertically and at each intersection on the fifth row horizontally.

Forty-five buttresses, spaced at 14 ft. 2 in. around the outside of the wall, are 2 ft. wide and project beyond the 14-in. wall about 11 in. at the top and die out at the base. These are reinforced vertically by ½-in. rods spaced 4 in. apart.

Every horizontal and vertical joint in the walls, which were built in courses about 12 in. high, was thoroughly cleaned before the next layer of concrete was laid. Any concrete work which had been standing twenty-four hours or more had the laitance removed by picks, wire brushes, and plenty of water, so as to insure a thoroughly sound bond.

On the completion of the work the wall, floor, and columns were painted with hot liquid bituminous asphalt, and afterward washed with lime.

The timber work necessary to form the internal surface of the wall consisted of bents erected about 14 ft. apart; the girts were spaced every 5 ft., and on each row of girts 6 x 6-in. beams were placed. The one facing the studding had a segmental piece nailed on to its face to form the curve. On the top of the 6 x 6-in. timbers were the gangways, which served to transport the materials. As the wall was built up to the level of the runways the timber work was made higher so as to command the next tier of concrete work.

Roof

The roof is constructed of 15-in. 60-lb. steel beams, cut to fit the 20-ft. spans and resting on the columns, which are 20 ft. apart each way. The joists are 12-in. 31-lb. beams placed 6 ft. 8 in. on centers, and attached to the primary beams by angle clips. The cover of the roof consists of a 5-in. concrete slab, reinforced with ½-in. steel bars laid crossways at 6-in. centers. The roof has a dome formation, being 12 in. higher at the center than at the perimeter. The surface of the concrete was washed with hot liquid asphalt to prevent disintegration by frost.

Rolled-steel joists were selected for the roof construction, as otherwise it would mean erecting falsework to a height of 27 ft. to support the reinforced-concrete beams. With the steel joists, however, the forms rested on the flanges and made a simpler and equally effective mode of construction.

The steel joists were elevated to the roof level by means of a fixed boom attached to the hoisting tower, which was used to raise the concrete. They landed on loose dollies and were run within reach of a placing derrick, built of 6 x 6-in. timber in the form of a double-boom traveler, having a reach of 60 ft. when both booms were spread. It was slid along greased rails and carried a set of chain blocks at the end of each boom.

All pipes fixed in the concrete were uncoated and had puddle rings cast on to prevent any water finding its way along the outside. These rings are 6 in. wide and 1 in. thick, strengthened by brackets 1 in. thick. All inside pipes have bell mouths. The inlet and outlet pipes stand 6 in. above the floor level.

All valves are located outside of the reservoir, and are inclosed in reinforced-concrete manholes measuring 3½ ft. square at the top and 3½ x 4½ ft. at the valve level. The mains leading to and from the reservoir are of ample size to deliver at least 5,000,000 gal. per day, and are of such dimensions as to fit in with future extensions.

Handling the Concrete

For the floor, columns and wall the concrete was specified to be a 1:1½:3 mix, but the mass work round the pipes, in the valve chambers, and in the roof cover was to be a 1:2:4 mix. The pit gravel obtained in the vicinity was found to conform so closely to the specified proportions that a mixture of 1 cement to 5 pit gravel was substituted, care being taken to add more cement when necessary. About 3400 cu. yd. of concrete were laid. The limiting compressional stress in concrete was 500 lb. per square inch.

Concrete was mixed wet in a ¾-yd. steam-driven Smith mixer and elevated by means of an Insley automatic roller hoist to an Insley receiving hopper situated a few feet above the level of working operations. Hand-drawn concrete hopper carts were wheeled over the gangways to all parts of the work.

A Ham-Baker water-level indicator was fixed to indicate the varying water levels, and, by electric transmission, to record the same at the Barton pump house, ½ mile distant.

A 20 x 10-in. Simplex Venturi meter, supplied by Francis Hankin & Company, has been installed on the delivery main to the reservoir and near the above-mentioned pumping station.

The ½ and ¾-in. steel rods were supplied by the Provincial Steel Company, of Coburg, Ont.; other steel was supplied by the Western Steel & Supply Company, of Regina; cement, by the Canadian Cement Company, of Calgary; cast iron, by the Canada Iron Corporation; and the concrete machinery, by Mussens, Ltd., of Winnipeg.

Itemized Costs

Some of the itemized costs are: Cast iron pipes, class C, 2¼ cents per pound; special castings, 5 cents; cast iron covers and ventilators, 4 cents; cement, $2.85 per bbl.; steel, ½ and ¾-in. bars, 2.44 cents per pound; 1-in., 2.80 cents; 1⅜-in., 3.21 cents; 15-in. joists, 3.6 cents; 12-in. joists, 3.9 cents; standards, 3.9 cents—all quotations f.o.b. Regina.

For placing steel in the columns the average cost of labor was 26 cents per 100 lb.; in the floor, 12 cents, and in the walls, 30 cents. The cost of labor, team and coal for mixing and placing concrete in the column footings averaged $2; in the columns, $10; in the floor, 82 cents; and in the walls, $1.10 per cubic yard.

Tenders were invited for the construction of this reservoir on the understanding that the city would supply all cement, gravel, steel and cast-iron work, with the result that the lowest bid was $63,176. The engineer's estimate was $46,497, to which was to be added $6974 for contractor's profit. The offers were considered too high and it was decided to carry out the work on force account under the superintendence of Mr. Herbert Gibson. The total cost was about $88,000, of which the items the city would have supplied under the contract absorbed about $58,000. The modifications in the design and specifications no doubt effected some reduction in the cost.

Mr. Theodore Brockmann was resident engineer during the first season. Mr. L. A. Thornton, the city works commissioner, took an active part in the organization of the work, and Mr. J. McD. Patton, followed by his successor, Mr. J. Mackay, waterworks superintendent, arranged for the materials. The reservoir was designed and its construction supervised by the writer.

Road Improvement in Ontario is to be aided by an appropriation of $5,000,000 made by the government of the province. A commission of two engineers and one member of the legislature has been appointed to investigate and report on the necessity for the construction and maintenance of public roads within the province.

Extent of the Steel Industry

A census of the rolling mills and steel works was taken at the close of the year 1912 and the number of completed plants, as given in the bulletin of the American Iron and Steel Institute, was 661, located in thirty-three states, the District of Columbia and the Canal Zone, Panama, of which 565 were active during the year and 96 were idle. At the close of 1911 the number of completed works was 647, of which 543 were active and 104 were idle. There was a gain in 1912 over 1911 of 14 completed plants.

The number of works which were equipped with hot trains of rolls at the close of 1912 was 445, of which 373 were active during the year and 72 were idle. The number of steel plants which were not equipped with hot trains of rolls at the close of 1912 was 216, of which 192 were active that year and 24 were idle.

In 1912 there were 29 rolling mills and steel plants added to the list of completed works, located in 12 states and the Canal Zone, Panama, of which 8 were equipped with hot trains of rolls and 21 were not, as follows: Rhode Island, 2; New York, 2; New Jersey, 1; Pennsylvania, 5; Texas, 2; Ohio, 2; Indiana, 1; Illinois, 5; Michigan, 4; Iowa, 1; Kansas, 2; Washington, 1; and the Canal Zone 1.

At the close of 1912 there were 11 rolling mills and steel works in course of erection, of which 7 were being equipped with hot trains of rolls and 4 were not being so equipped, as follows: Pennsylvania, 2; Maryland, 1; Alabama, 1; Ohio, 3; Michigan, 1; Minnesota, 1; and Washington, 2. In addition at the close of 1912 there were 5 plants which were partly erected but upon which work had been temporarily suspended.

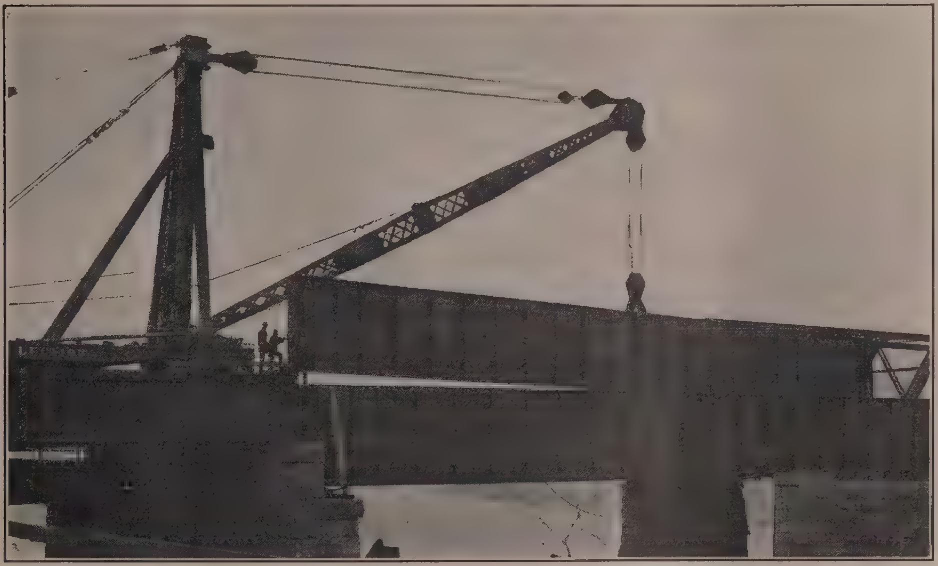
During 1912 there were 19 rolling mills and steel works abandoned or dismantled, located in 10 states, of which 12 were equipped with hot trains of rolls and 7 were not, as follows: New York, 3; New Jersey, 1; Pennsylvania, 6; Delaware, 2; Maryland, 1; West Virginia, 1; Alabama, 1; Ohio, 2; Illinois, 1; and Michigan, 1.

Automobiles for the Division Engineers of the Wisconsin State Highway Department have been purchased by the highway commission with a view to doubling the efficiency of the seven men who have in their charge 1400 pieces of road improvement.

Erecting 110-Foot Plate Girders with a 60-Ton Derrick Car

The plate-girder approaches for the 401-ft. double-track span carrying the Pennsylvania Railroad over the Monongahela River at West Brownsville comprise two 100-ft. spans at the west end and one 110-ft. span, one 59-ft. span and one 26-ft. span at the east end. Each of the 100-ft. spans has two tracks carried on separate pairs of girders on masonry piers. The other spans provide for a diverging third track which required five 110-ft. girders, and six girders for each of the shorter spans.

All the girders were erected by the Lucius Engineering Company, of Pittsburgh, with a 60-ton derrick car having a 65-ft. boom. The eight 100-ft. girders weighing 28 tons each were first erected and the derrick car was turned around and moved across the river on the old structure. The 101-ft. girders, each weighing 55 tons, were delivered to it on cars at grade and swung into position. Their erection developed a concentrated load of about 170 tons under the front tracks of the derrick car, which were relieved of this great stress by a system of solid blocking built under the car framework and the ends of the inclined outriggers to transmit the load to the bridge structure. The 35 and 90-ft. girders were riveted up in pairs to form complete spans, which were handled by the derrick cars.



Erecting a 110-Foot Plate Girder with a 60-Ton Derrick Car

The derrick car, illustrated on this page, has a steel A-frame with steel outriggers to provide increased lateral stability, and inclined steel rear braces opposed to which are adjustable back stays from the top of the frame to the rear of the car platform. When the heaviest girders were lifted the top of the A-frame was additionally secured by back stays anchored to a ballast car in the rear and adjustable by a tackle at the upper end. The steel was fabricated and the main span was erected by the Pennsylvania Steel Company.

Fighting Mosquitoes was one of the construction problems of the power development at Stave Falls, B. C. Two years ago the pests were so annoying at the height of the mosquito season that for two weeks work was suspended altogether. This season there have been practically no mosquitoes at all, it is reported, as a result of having a man detailed to spend his time putting oil on pools in the neighborhood.

Railroad Bridge Moved to New Site for Highway Service

The provincial government of British Columbia recently decided to build a combined highway and electric-railway bridge over the Pitt River, a few hundred yards above the point where this stream is crossed by the main line of the Canadian Pacific Railway. While plans were being prepared for the government bridge the railroad company was constructing piers for a double-track bridge to replace the single-track structure across Pitt River. A description of the Pitt River Bridge foundations appeared in this journal on June 28. It was suggested that the abandoned single-track railroad bridge, which is a comparatively new structure, might be moved in complete sections and placed upon new piers at the location selected for the government highway bridge.

This plan was found to be feasible and the government bought the railroad bridge at a figure said to be highly satisfactory to both parties, as it relieves the railroad company from the necessity of dismantling the structure and makes it possible for the government to open the new highway a year ahead of the expected date. Plans for the highway bridge piers are being revised so as to accommodate the railroad spans, which will fit nicely in the new location, drawspan and all, because the river width is practically the same at both points. The only change in the superstructure moved to the new location will be the construction of a flooring suitable for highway traffic.

Moving of Spans

The largest span to be moved is the 250-ft. drawspan, which weighs 400 tons. This was taken from its original location on Aug. 20 and placed upon pile supports near the site for the highway bridge. The actual moving was accomplished in less than an hour, four scows being used to float the span, and a tug at each end serving to move it to the temporary supports. The scows were each 30 x 80 ft. in plan and 8 ft. deep and a framework of 12 x 12-in. timbers was erected on each to bring the bearing up to the required height.

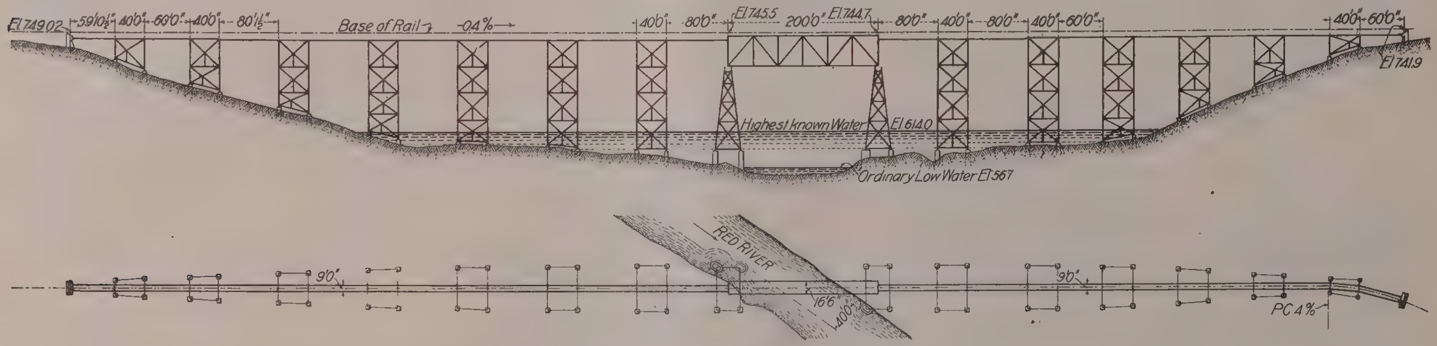
When ready to move the drawspan, the scows were partly filled by drawing plugs, so that the framework on each would just pass beneath the floorbeams of the bridge. The scows were placed athwart the bridge, one at either end and one on each side of the pivot pier. On each of the four scows were two 4-in. diaphragm hand pumps, and each pivot-pier scow was also served by a 4-in. steam-driven centrifugal pump, while the outer scows, to which the tugs were attached, were tapped by the steam pumps on the tugs. When the floating supports were accurately placed, pumps were started, and the rising scows lifted the steel span from its piers.

The effective width of the bridge resting upon supports was about 20 ft., and this was found to be sufficient to give the span ample stability when floated on the 80-ft. scows, although the upper chord was about 60 ft. above water at its mid point. After being floated the span was towed several hundred yards upstream and swung through a quarter turn. A kedge anchor was then placed to hold it steady in the current, and the line was paid out slowly until the structure was eased carefully into position over the temporary piers prepared for it near the river bank. When in exactly the right position over the rest piers the plugs in the scows were drawn again and the span settled safely to the supports.

New Cutoff between Winchester and Irvine, in Eastern Kentucky

Heavy Grading in Broken Country Intersected with Narrow, Deep Ravines, and High Viaducts across Valleys

Of all the new construction and grade revision work being done by the Louisville & Nashville Railroad at this time in three states some of the heaviest is on the 26-mile cutoff from Winchester to Irvine. This line traverses broken country cut with deep ravines. Although the other railroads in the general vicinity wind around to follow the drainage, this one cuts across the drainage and does not deviate far from a straight line connecting the two termini. The line will be used chiefly for coal, and as it will not serve any very large population there will be no fast passenger service, and sharper curves have been permitted than were used on the main-line work described in earlier articles. The curvature is, however, confined to a maximum of 6 deg. The ruling grades are 0.4 per cent northbound against loaded traffic and 0.5 per cent southbound against empties. In order to obtain these grades it was necessary to "force" the ground, the summit cuts being long and deep and the valleys being crossed on high viaducts.



General Plan and Elevation of Red River Viaduct, with Principal Dimensions and Elevations

Throughout the work the grading is heavy, although the material varies gradually from a hard, durable limestone at the north end to less durable shales and slates, and again to soapstone which, although it can be removed only by blasting, crumbles away a day or two after it is exposed to the air, and gives much trouble by sliding. Most of the slopes were steep, and the excavating equipment had to be hauled along the tops of the ridges. The fills are mostly short and deep, across ravines, and were in many cases too high to place from single-deck trestles.

The route of the line was shown in the preliminary article on the Louisville & Nashville work, on page 99 of the issue of July 26, 1913. Leaving the Cincinnati-Atlanta line at Winchester, the new route descends on the ruling grade, regardless of the direction of the drainage, for a distance of about 16 miles, or about 3 miles beyond the Red River crossing. It then ascends for about 2 miles to the Mobley Hill summit and again descends into the Kentucky River Valley, which it follows into Irvine, remaining, however, well above high-water mark.

Winchester Cut

The beginning of the long descending grade from Winchester is determined by the grade crossing of Broadway Street in that city. Between this point and the junction of the old and new lines about ¼ mile south the old track profile is being cut down a maximum of 9 ft. This cut of 70,000 cu. yd. is in the city of Winchester. To prosecute the work without interrupting traffic on the old line it was necessary to shift this line, and on account of a street crowding the right-of-way closely on the west side this shift could be made only to the east. This necessitated a temporary crossing of the Cincinnati-Atlanta line over the new cut as it turns away. When this cut is finished and the old profile from the junction south is adjusted to it, the tracks will be shifted to the bottom of the cut and the temporary crossing will be removed.

Winston & Company, of New York City, have a general contract for the entire work. They have sublet it in sections, and the subcontractors in turn have sublet portions of the work. About 3½ miles from Winchester is the Burch cut, which is 1200 ft. long, with a maximum depth of 90 ft. About 2 miles beyond this is the Raker Tunnel, which is only 547 ft. long and involved no special difficulty. This work is all being done by Johnson & Briggs, of Winchester. The quantities throughout are heavy, but the country is somewhat less broken than that farther south.

About 1 mile south of the Raker tunnel is the crossing of the Dry Fork. This will be a five-span bridge 500 ft. long and 85 ft. high. The concrete work is completed, but the steel is not yet on the ground. The concrete work was done by Sturm & Dillard, of Columbus, Ohio. The concrete mixer and the crusher plant were located at the bottom of the valley. The limestone rock being taken from the cut near by was used for the concrete, the dust being used in place of sand.

A short distance south of Dry Fork crossing is another short tunnel, the Conkwright. No special difficulties were encountered with this tunnel, but throughout the 3 miles from Dry Fork to Howard Creek the grading is heavy and the material is difficult to handle on account of the succession of short, deep cuts and fills. The grading is also being done by Sturm & Dillard.

Cableway for Fills

To make the high fills a track suspended from a cableway was used successfully. On the solid ground at each end of the fill a bent made up of two heavy end posts and a cross-timber at the top was constructed from large tree trunks available in the vicinity. Two 2-in. cables were then carried across the ravine and drawn tightly over the tops of the bents, the ends being firmly anchored in the ground beyond, with a ⅞-in. triple block at each end of the cables to allow tightening or loosening of them. At 10-ft. intervals a hanger of ¾-in. cable was suspended from each main cable, being firmly secured to it to prevent sliding. The corresponding hangers held the ends of timbers at right angles to the line of embankment. A pair of stringers spaced about 4 ft. apart spanned between timbers, and the narrow-gage track was laid on the stringers. To make each part of the track adjustable as to height, each hanger had a double adjusting block with ⅜-in. cables. The main cables and the corresponding hangers were first spaced 12 ft. apart, but for the second fill this was increased to 13 ft. to give more room for righting the empty cars.

In operation the 4-yd. side-dump cars were pushed out in trains, each one being dumped as it came upon the end of the suspended structure, so that the cables had to support only the empty cars. The cableway system was used successively at three points, the span from tower to tower being in each case about 600 ft. In two instances a single ravine was spanned; in the third two narrow ravines with a short low intermediate cut were taken care of. The same cables, blocks and timbers were used at one fill after another, there being no dead loss in trestles permanently buried. The danger was also eliminated of the material knocking the high trestle bents over in falling, or pushing them out by sliding down the steep-sided ravines.

The cables were furnished by the John A. Roebling's Sons Company, of Trenton, N. J. The contractors are taking the cuts out with a Bucyrus 70 and a Marion 60 steam shovel and handling the material in 4-yd. narrow-gage Kilbourne & Jacobs side-dump cars hauled by one Porter and four Vulcan dinkeys.

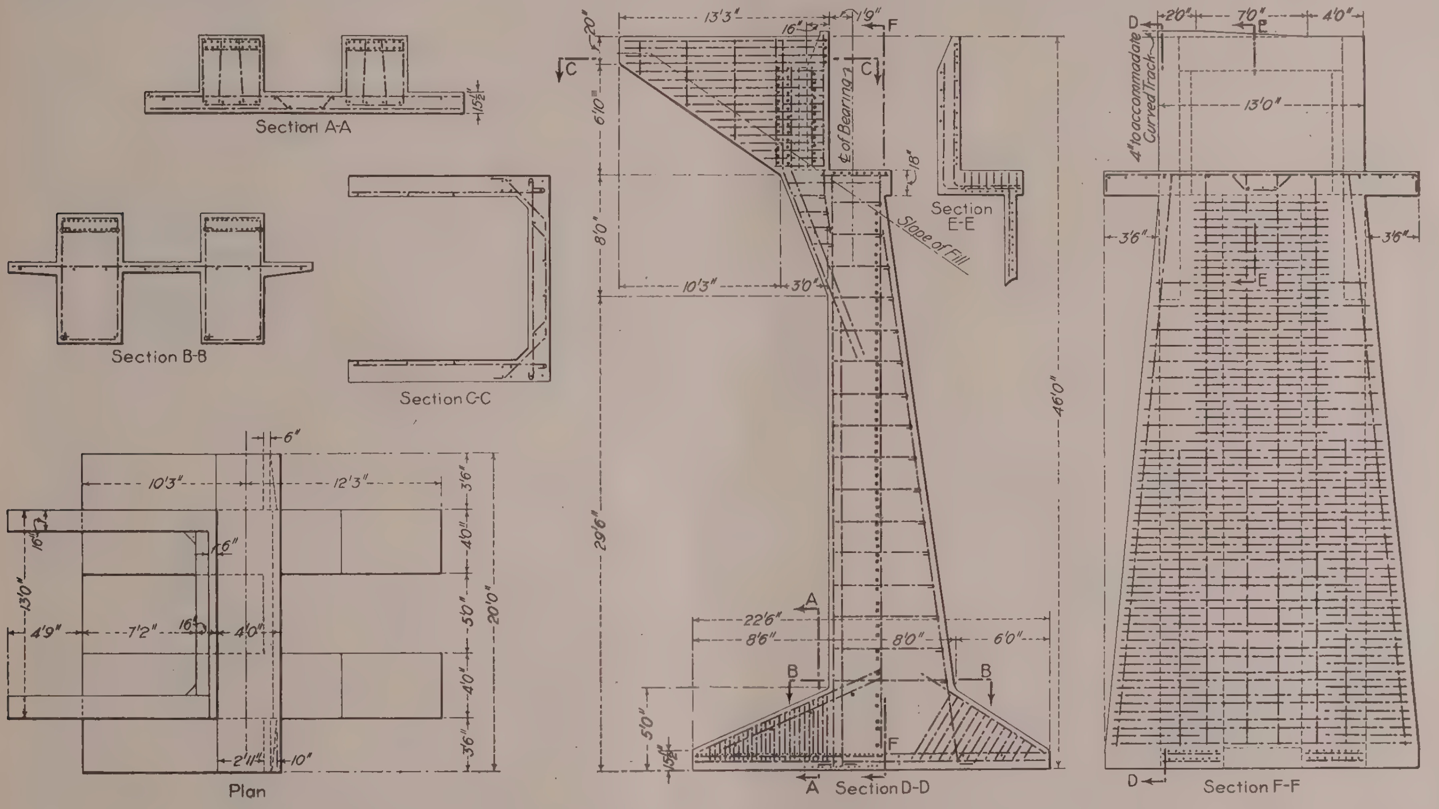
Howard Creek will be crossed on a viaduct 1235 ft. long and 170 ft. high. The concrete abutments and pedestals are being constructed by J. M. McClusky, of Louisville, who is also building a number of the arches and box culverts. No steelwork has as yet been done. South of Howard Creek a stretch of smoother ground is encountered. Sims & Company, of Winchester, sub-contractors, are doing the grading here, using two Marion 60 steam shovels and 12-yd. standard-gage side-dump cars hauled by four second-hand yard engines. A small portion of this work is being done with mules and carts, the material handled by the mules being mostly earth or soft shale.

Ravine Crossing Near Red River

A short distance north of the Red River crossing, which is a little less than 4 miles from Howard Creek, the line crosses a deep ravine. Although the fill across this is only about 300 ft. long, the depth is 90 ft. on the center line. The bed of the Creek has a sharp fall, and the fill at the upper toe is only 70 ft., while that at the lower toe is 130 ft.

On the north slope of the ravine there is a public road, which also had to be accommodated.

The stream, which is a small one, is taken care of by a 36-in. pipe. This starts at the upper end from the creek level, but is kept up along the slope of the ravine, so that the lower end is some 40 ft. above the old creek bed, thus reducing the length of pipe to about 250 ft. and giving a 5 per cent grade. The public road has been relocated on the north slope well up toward the top, and is carried under the tracks through an opening 12 ft. wide with vertical side walls and a semicircular arch. This arch is of the general type adopted by the company for undercrossings, except that it is crowded so close to the bank that the north wing walls are eliminated.



Reinforced-Concrete Stub Abutment, with Spread Footing, Web-and-Counterfort Body, and Cantilevered Wings

The grading is being done by J. C. Carpenter & Company, of Clifton Forge, Va. The fill was started from a trestle, which was in reality one trestle on top of another, the height being too great for the ordinary type of trestle. The material was taken out with a steam shovel working in a fairly heavy cut about ½ mile south, at the brink of the Red River Valley, after the smaller intermediate cuts and fills had been made. Owing to the long fall for the material, practically all of which is rock, and the steep sides of the ravine, inviting slides, substantial bracing was used to save the trestle from destruction; but in spite of this the trestle was destroyed and the embankment was completed from a cableway.

The concrete arch for the road was built by the Emery Contracting Company, of Tamaqua, Pa. The concrete plant was located on the south side of the ravine, partly because there was more room there and partly because the same company was building the masonry for the Red River viaduct, which is on that side. The trestle was floored over to form a walk which extended to a platform over the arch, and the concrete was wheeled across in buggies loaded by means of a chute from the Smith mixer, which was somewhat higher than the trestle. In order not to interfere with the work of making the fill the concrete was placed mostly at night.

Red River Bridge

At the Red River there will be a bridge 1800 ft. long and 180 ft. above low water. As the illustration shows, this will be of viaduct construction, with alternate spans of 40 and either 60 or 80 ft., except for the channel span, which will be a deck truss of 200-ft. span, supported on wedge-shaped steel towers about 56 x 34 ft. at the base. The river channel, which is about 80 ft. wide, is on a sharp skew, and three of the tower pedestals, two on the north side and one on the south, will be in the river. These three will be elongated, with semicircular ends, and will be turned parallel to the river channel, the government requiring a 40-ft. clear waterway normal to the line of the channel.

On each side of the main span the ground is almost flat for several spans, after which it rises on a fairly steep slope to the sub-grade level. On either side of the river two concrete plants were used, one near the bank of the river and the other on the hillside near the abutment. One derrick reached the lower plant, the channel-span tower and the nearest pedestals of the next one. In the same way another derrick reached the upper mixing plant, the abutment, and the adjacent pedestals. The concrete was conveyed to the other pedestals on the flat ground in buggies run from the lower mixer, and that for the pedestals on the slope was let down from the upper mixer on an inclined track.

South from the Red River the Jones-Gray Construction Company, of St. Louis, has a sub-contract for the grading for about 3½ miles. This is mostly sidehill work. A variety of equipment is being used. Some of the shallow cuts are being made with mules and carts. For the heavier ones a Marion 40 steam shovel and a Vulcan 70 with a 3-yd. bucket are being used, loading into standard-gage 6-yd. cars hauled by two second-hand yard engines. Another type of cableway for placing the deep fills has been used on this section. It consists simply of a track laid part way out on cables stretched across the ravine. This system has not proved stable enough for the heavy standard-gage equipment used, and several derailments have occurred.

Another viaduct 360 ft. long and 88 ft. high is to be built across a small valley 3 miles south of the Red River crossing. Work has not been started here. The abutments are to be of the reinforced type being used on a number of the Louisville & Nashville bridges, and some of the details are shown. In most respects the design is similar to that shown for one of the Cumberland River bridge abutments, on page 129 of the issue of Aug. 2, 1913. The footings differ noticeably, however, as well as the bridge seats and back walls.

Adjoining the Jones-Gray contract is that of J. M. Hassett & Company, of Cincinnati. One of the features on this contract is the Mobley Hill cut, which is 3200 ft. long, with a maximum depth of 108 ft. This depth prevails only through a thin ridge, long shallow extensions to the cut being necessitated by the fact that the final sub-grade will be 20 or 30 ft. below the comparatively gently sloping ground at the base of the ridge on either side. A public road ran along the top of the ridge, and this had to be relocated, bringing it down to an overhead crossing at a lower level south of the ridge. South of the cut the new line runs into a ravine, the profile being considerably below the bed of the creek for several hundred feet, and an extra-wide ditch will be required to take care of the water.

About 1½ miles south of this cut is a 75-ft. fill, involving 122,000 cu. yd., over the Polecat Branch, the water of which is taken care of by a 5 x 4 reinforced box culvert. Immediately north of this fill there is a heavy cut, and all the way between this point and the Mobley Hill cut the grading is heavy.

One of the problems on this section of the work was to get the steam shovels and other equipment to the site of the work. The country south of the Red River, in the fork between it and the Kentucky River, is but sparsely settled, and the few public roads are crude, with heavy grades, and ferries at the river crossings. The ten steam shovels at work in this section were all loaded on barges at Ford, where the Cincinnati-Atlanta line crosses the Kentucky River, and floated up to convenient points for unloading. The general map in the first article shows the situation. One temporary railroad was built up the sidehill from the Red River for the Jones-Gray equipment and another up the Polecat Branch from the Kentucky River brought up the Hassett shovels.

Arrived at the new right-of-way, there were other difficulties in getting them into action at the most advantageous points and in moving them from one cut to another. From Mobley Hill south the line is generally on sidehill, intersected with ravines and sharp noses. At each large cut it was necessary to let the shovel down from above and begin at the top, using single or double switchbacks as necessary to get down to the grade of the fills. In some instances temporary detours were made around noses in order to facilitate long hauls from the cuts.

Polecat Fill

The Polecat fill is being made in two stages. A trestle about 40 ft. high was first built, and the embankment was placed this high to its full width. The material was obtained largely from the cut immediately north, a switchback down around the nose of the hill getting the track down to the trestle level. The track was carried on around the hill, and the rock from other cuts farther north was brought and placed in the same embankment. The first stage has been completed, and another trestle has been built on top to the desired height. A Marion 60 shovel and a Thew, one working near the Polecat fill and the other in the Mobley Hill cut, have gradually opened a way connecting the two; the detour around the first hill has been abandoned with the opening of the cut, one or two other detours have been constructed, and the upper lift of the large fill will be made largely from the Mobley Hill cut.

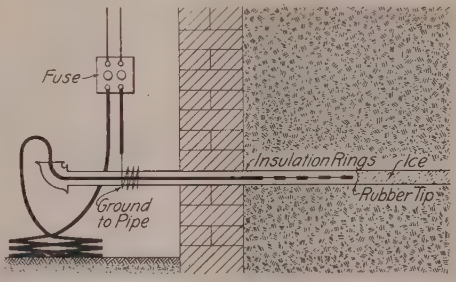
The top stratum of rock along here is hard limestone, but so seamy that blasting often fails to break it up so it can be handled with the shovels. Below the limestone there may be shale or slate, and below this is soapstone. In the low places the limestone and the slate have disappeared, and the earth above the soapstone exhibits a strong tendency, with the weight of the fills, to push out on the lower sides in waves. To overcome this difficulty it has been found expedient to drill holes 10 or 15 ft. deep at the downstream side at the toe of the embankment and "shoot" them, roughing up the surface and giving the embankment a foothold.

A part of the Hassett subcontract has been resublet to D. J. Grant & Company, of Cincinnati. The same conditions prevail here. A 60-ft. cut, known as the Wiseman, is being taken out with a Marion 60 shovel, the last in this territory, and hauled with two Vulcan dinkeys in 4-yd. Western side-dump cars.

From here to about 2 miles north of Irvine little work has been done. Another viaduct 420 ft. long and 65 ft. high will pass over Calloway Creek. A short distance from Irvine a concrete arch is being built over White Oak Creek by the Emery Contracting Company. The creek is a large one, requiring a 52-ft. opening; but in order to get a rock foundation it was necessary to go down some 20 ft. Thus most of the arch is being built below the original ground level, and only a small part of the top shows from a distance. The arch ring is being built between cofferdams on either side about a third of the way up from the springing line. Piles driven between the cofferdams support the centering for the middle section. After the ring has been completed and the waterway cut down to the new level the piles will be cut off.

Slide at Irvine

A short distance beyond this the new line passes under the present line from Richmond, which swings around and rejoins the new location just north of Irvine station. The main street in Irvine, 120 ft. or so above the Kentucky River, comes out to the end of a nose dropping abruptly into the river, and is built up with stores to the end. The old line curved sharply around this nose and reversed to cross on a trestle a deep ravine just south. To avoid this sharp curvature the new location contemplated crowding in some 15 ft. at the nose, and making a high fill close to the river's edge in place of the trestle. Here as elsewhere soapstone was encountered, and for several hundred feet the toe of the new fill has slid out into the river from 75 to 100 ft. This is about a quarter of the way across the river, which is navigable, and the Federal government requires that the channel be restored to its full width. The nature of the material makes it doubtful whether the slide can be removed without precipitating a worse one, but it is hoped that this can be done by relocating the line more nearly on the site of the old one and using extreme care in restoring the channel to its proper width.



Connections to Frozen Pipe

From the Calloway Creek crossing there are few curves, and the grades are light. The grading at the Irvine end is largely completed. The Burton Construction Company, of Richmond, Va., is doing the work, using two Marion steam shovels.

The steel work for the larger number of bridges on the improvements under way in Eastern Kentucky has been contracted to the Foster-Creighton-Gould Company, of Nashville, Tenn., which, in turn, has sublet the furnishing of the steel to the Virginia Bridge & Iron Company, of Roanoke, Va.

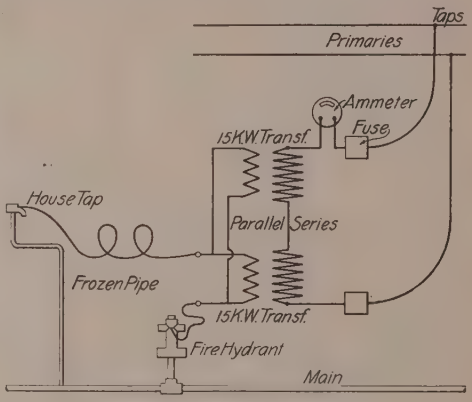
The cutoff is being built under the general direction of Mr. John Howe Peyton, chief engineer of construction, who, with Mr. S. F. Ferguson, located the line. Mr. W. H. Courtenay, chief engineer, has charge of the detail designs. Mr. E. D. Sloan, assistant engineer, is in local charge of the work. The line is divided into three residencies. Mr. J. M. Walker has the Winchester end, including the Burch cut, the tunnels and the Dry Fork viaduct; Mr. G. R. Smiley has the middle section, including the Howard Creek and Red River viaducts and a smaller one; and Mr. J. H. Bailey has the Irvine end, including the Mobley Hill cut.

Electric Thawing of Frozen Water Pipes

The use of electric current to thaw out frozen water pipes has increased in a marked degree during the past few years and several manufacturers at present supply special pipe-thawing transformers and equipment. An unusual rig of this kind, employing a series-parallel connection of transformers, was used during the past year by a central station in the northern part of the United States. The motor trucks used were equipped with pairs of 10-kw or 15-kw transformers connected in series on the 2300-volt side and in parallel on the 110-volt side. A coil of wire used in series with the transformers has sufficient resistance to limit the current flow to 200 or 300 amp, and the switch is left closed until the pipe is freed.

Equipment Used

To meet the emergency of 2000 calls for pipe-thawing assistance last year, a large metropolitan company employed the equipment connected up as shown in the accompanying drawing. Except for the primary fuses, no current-limiting or measuring devices were employed. The first crews equipped were provided with meters, but these were found to be unnecessary after the men had gained a little experience and confidence. Current of 200 to 300 amp was used at 50 volts, the average duration being from 5 to 15 minutes. It is estimated that from 2 to 4 kw-hr. were required per service thawed. Only the cost of the men's time was charged to the customers, this expense averaging about $11.50.



Plan of Electric Wiring

Thawing without Transformer

A less elaborate, although slower method than the above, requiring no transformer or other apparatus, is to cut the insulation from a piece of No. 8 weatherproof wire as shown in the accompanying drawing. After disconnecting the house piping the wire is threaded into the frozen service line, to which the other side of the circuit is grounded. An elbow screwed on the end helps hold the water in the pipe to provide a conducting path, and the current flow is limited by a 20-amp fuse.

Such a water rheostat method thaws at the rate of 3 to 4 ft. per hour. In one case a 16-ft. frozen section was thawed at the expenditure of 10 kw-hr., costing $1. Only one man was required, and after starting the job he turned it over to a boy to feed the wire into the pipe, as the ice was melted. For thawing a few services in houses where electricity is available the electrolytic method may, therefore, prove to be very convenient and economical.

Uniformity in Sewer Plans

New Jersey State Board of Health's New Regulations Governing Preparation and Submission of Designs for Sewer Systems and Treatment Works

At a recent meeting of the Board of Health of the State of New Jersey a set of rules and regulations governing the submission of designs for waterworks or sewage works was adopted. These rules have been under consideration for about a year, and the necessity for them has increased daily. Plans are submitted at the present time in all sizes up to 6x10 ft., and on all kinds of paper from the wrapping kind to tracing cloth.

It is also an unfortunate circumstance, the board reports, that some few engineers who have worked along other lines will accept work designing municipal sewage-disposal or water purification plants apparently without investigating the underlying principles as thoroughly as is desirable. It then becomes necessary for the state authorities to gather detailed data regarding the project, which very often cannot be done as efficiently as would be best because of the small number of engineers which may be employed with the present annual appropriation.

The present rules are therefore intended to prevent loss of time incident to the collection of fundamental data upon which the design is based, and also to make the plans and reports more uniform in character. Before taking final action upon the regulations they were submitted to several of the leading sanitary engineers, with the request that comments and criticisms be made. It was the intention of the board to see that no unjust provisions should be included which would cause unnecessary expense or hardship upon the part of the engineers.

The regulations were prepared by Mr. C. G. Wigley, engineer of the board, under the supervision of R. B. Fitz-Randolph, chief of the division of food, drugs, water and sewerage, and adopted by the Board of Health of the State of New Jersey June 23, 1913.

The rules relating to plans for sewers and sewage treatment works are reprinted below:

SEWERS AND SEWAGE TREATMENT

Submission of plans (1).—Plans shall be submitted to the board for examination at least two weeks prior to the date upon which action by the board is desired. From this it is not to be inferred that action by the board will always be taken within the time mentioned.

Information required (2).—The plans for a complete sewerage and sewage disposal system shall include the following: A general map of the municipality or sewerage district; profiles of all sewers proposed; details of construction of manholes, flush tanks, and special structures pertaining to the sewers; general and detailed plans for disposal works; a comprehensive report upon the proposed system by the designing or consulting engineer, to be written upon letter-size paper, and the sheets firmly bound together; a preliminary report, containing data and information sufficient for the complete understanding of the project may be submitted to the State Board of Health for their consideration, prior to the submission of detailed plans.

Map or general plan (3a).—The general plan referred to in paragraph (2) shall be drawn to a scale not greater than 100 nor less tha 300 ft. to 1 in.; and shall show the entire area of the municipality or district. If the municipality is greater than 2 miles in length the map may be divided into sections, conforming in size to those mentioned in section 7 of these rules. The sheets shall be bound together and a small index map supplied, showing by number the area covered by the various sheets. A general plan shall accompany each application, in the case of a new sewer system or any extension or modification of any existing sewer system unless such general plan has already been submitted.

Details of map (3b).—This plan shall show all existing or proposed streets, the surface elevations at all street intersections, and contour lines at intervals of not more than 10 ft.

If it is intended to defer the construction of sewers in some of the streets, the plan shall show that sewerage facilities are provided for all such sections of the municipality or sewerage district. The plans shall also clearly show the location of all existing sewers, either "separate" or "combined," the location of the disposal works and the location of existing and proposed sewer outlets or overflows. The true or magnetic meridian, the town or borough lines, title, date, scale, direction of flow and average water elevation of the stream shall also be clearly shown. The elevation of the highest known freshets at the outlets and site of the disposal plant shall be given. Any area from which sewage is to be pumped shall be shown by light shading, coloring or other distinctive marks.

Lettering and symbols (3c).—Letters and figures shall be clearly and distinctly made. Sewers to be built at present shall be shown by solid lines, and sewers to be constructed later shall be shown by a line of dashes as - - - - - - -. Existing sanitary sewers shall be shown by the following symbol, ..., and combined sewers by a dot and dash, .—.—. All topographical symbols used are to be the same as those of the U. S. Geological Survey.

Elevations (3d).—Elevations of the surface of the streets should be placed outside the street lines in the upper right angle, or opposite their respective positions in the street. The elevations of sewer inverts should be shown at street intersections, ends of line, and wherever a change of grade occurs. The elevations of the sewer shall be written close to the point to which they refer, parallel with the sewer line and between the street lines. The elevations of surface shall be shown to the nearest 0.1 ft.; those of the sewer invert to the nearest 0.01 ft. The sizes and gradients of all proposed and existing sewers shall be marked along the line of the sewer.

Sewer appurtenances (3e).—All sewer appurtenances and unusual features, such as manholes, lampholes, flush tanks, siphons, pumps, etc., shall be designated on the plans by suitable symbols and referenced by a legend near the title.

Profiles (4).—Profiles of all sewers over 8 in. in diameter and of all 8-in. sewers, where gradients less than that given below are used, shall accompany the application. Profiles of all sewers must be approved before they are constructed. Profiles of sewer lines shall be prepared and drawn to such a scale as to clearly show the structural features of the sewer. For ordinary use, the following scales are suggested: Vertically, 10 ft. to 1 in.; horizontally, 100 ft. to 1 in. Both scales must be clearly shown upon each sheet. Upon these profiles shall be shown all manholes, flush-tanks, lampholes, siphons and stream crossings, with elevations of stream bed and normal water. Figures showing the sizes and gradients of sewers, surface elevations, sewer inverts, etc., should be shown with the same frequency as required for the map.

Grades, etc.—The following gradients for sewers flowing half full are suggested as minimum grades for ordinary use, as with careful construction a theoretical velocity of approximately 2 ft. per second can be obtained:

Size of pipe	Fall in ft. per 100 ft. of sewer
8 in.	0.40 ft.
10 in.	0.29 ft.
12 in.	0.22 ft.
15 in.	0.16 ft.
18 in.	0.12 ft.
20 in.	0.10 ft.
24 in.	0.08 ft.

The sewers should have a capacity when flowing half full sufficient to carry twice the future average flow twenty-five years hence, plus a sufficient allowance for ground water infiltration. When grades lower than those given are used, an explanation and reasons for the use of such grades should be included in the engineer's report. On each sheet of profiles must be given, under the title, an index of the streets appearing on that sheet. Profile sheets shall be numbered consecutively.

Detail plans (5).—Detail drawings of sewer sections except where terra cotta or iron pipe is used, and of all sewer appurtenances, such as manholes, lampholes, flush tanks, inspection chambers, siphons and any special structures, shall accompany the general sewer plans. The detail plans shall be drawn to such a scale as to show suitably and clearly the nature of the design and all details, such as manhole frames and covers, iron pipes, valves, gates, etc.

Disposal works (6).—The plans for the disposal works shall include a general plan upon which reserve areas or future extensions are clearly shown, and detail plans of the various units and structures which comprise the plant. A weir or other measuring device shall be provided at some convenient point, and the installation of a recording device is recommended, and in particular instances may be required.

Detail plans.—The detail plans shall show longitudinal and transverse sections sufficient to explain the construction of each unit. They should also show the distributing and drainage systems, general arrangement of any automatic devices, sizes of stone, gravel, or sand used as filtering material, and such other information as is required for the intelligent understanding of the plans.

Drawings (7).—All drawing submitted shall be neatly and plainly executed and may be traced directly on tracing cloth, printed on transparent cloth, or printed on any of the various papers which give distinct lines. All prints shall be clear and legible.

Size of drawings.—With the exception of the map, the following dimensions are suggested for ordinary use: Distance from top to bottom, 20 or 30 in.; length, 24 in., 32 in., 40 in. or 48 in., or thereabouts. By this section it is intended to prevent the use of long profiles and unnecessarily large maps, which are difficult to file or to use.

Title.—Each drawing shall have legibly printed thereon the name of the town or persons for whom the drawing is made, the name of the engineer in charge, the date, the scale and such references in the title as are necessary for the complete understanding of each drawing.

Engineer's report (8).—A report, written by the designing or consulting engineer, should accompany all plans for complete sewerage systems, and shall give all data upon which the design is based, such as:

Information concerning sewer systems.—(a) The nature and extent of the area which it is proposed to include within the present system of sewerage, and of the area which it is planned shall ultimately drain into this system. (b) The population to be served, both present and estimated for twenty-five years hence. (c) The estimated per capita daily flow of sewage to be cared for. (d) The total and per capita water consumption of the town at the present time. (e) The allowance made for leakage into the sewers. (f) The estimated daily flow of sewage, including leakage. (g) The character of the sewage (whether domestic or including manufacturing wastes, and in case of the latter, the nature and approximate quantity of the same stated in specific terms). (h) Method of flushing or periodically cleaning the sewers. (i) That portion of the sewers to be built at the present time. (j) The minimum grades of sewers for each size used. (k) If there are sections which cannot drain into this system, the extent of such sections and the probable future disposition of the sewage from these sections. (l) Distance of sewer outlet from shore and depth of water at mean tide at outlet, if outfall discharges into ocean or large stream.

A list of bench marks or fixed elevations should be included in this report.

Information concerning disposal plant.—With regard to the disposal plant, the engineer's report shall cover the following subjects:

(a) The method of disposal to be adopted and a description of the units of the system. (b) The rate of working of each unit. (c) If disinfectant is to be used, the name of the disinfecting substance, the quantity per million gallons of sewage and the method of application. (d) The nature of the body of water into which the effluent discharges, with particular reference to the run-off during dry weather. (e) The disposal of sludge. (f) All conditions peculiarly characteristic of the locality and which in any way affect the design of the system. (g) Special devices used in connection with the disposal system. (h) Special methods of maintenance or operation of the system. (i) The results expected from the purification system. (j) Explain any provisions for reserve units in pumping plants, pipe lines, filters, etc.

Specifications and estimate of cost (9).—Specifications for the construction of the system of sewers and sewage disposal works and an estimate of the cost of the same shall accompany all plans for new or original systems. With plans for extensions of existing systems, specifications may be omitted, provided that these extensions are to be constructed in accordance with specifications filed previously with original plans.

Extensions of present systems (10).—If the plans are solely for the extensions of an existing system, then only such information as is necessary for the comprehension of the plans will be required. This information must in general conform to the above requirements for a complete system.

General requirements; application for approval (11).—The application for approval of plans shall be made by the proper municipal authorities, persons for whom the work is to be done, or their properly authorized agents, upon blank forms which will be supplied by the board.

Systems on separate plan.—Under ordinary circumstances the board will approve such plans only when designed upon the separate plan, in which all rain water from roofs, streets and other areas and all ground water, other than unavoidable leakage, is to be excluded.

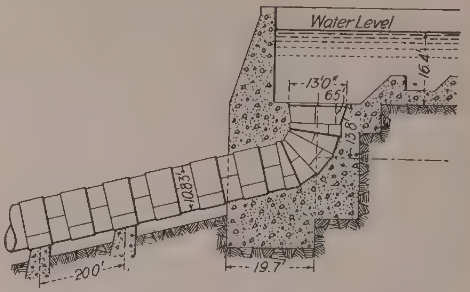
By-passes.—No by-passes which may allow raw or partly purified sewage to be discharged from the sewers or disposal works shall be included in the plans, except by special permission of the board.

Deviation from approved plans.—No deviation from approved plans shall be made, unless amended plans, showing such proposed changes, have been submitted to and approved by the board.

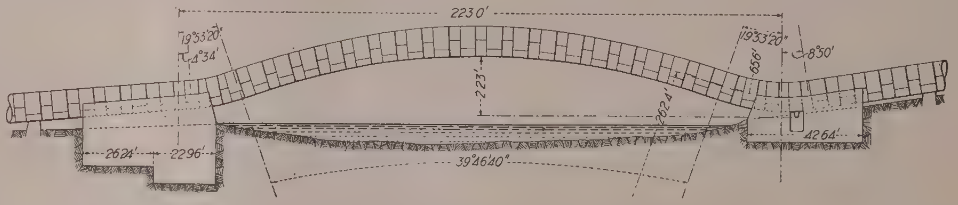
[The rules relating to water supply and water purification systems will be published next week.]

Self-Supporting Arched Penstock

A penstock having many unusual features, as shown in the accompanying illustrations, is installed at Saint Jean de Maurienne, in the Province of Savoie, in France, and is designed to carry 950 sec.-ft. at a velocity of 10.32 ft. per second. The water, collected in the French Alps, is conveyed by a 13,100-ft. tunnel to the forebay. This forebay, as shown in the drawing, is provided with sedimentation basins, which can easily be cleaned by opening a sluice gate. Should any wave action due to irregularities in the water demand occur a concrete spillway will discharge the surplus until normal conditions have been again reached. A concrete-lined chute conveys the discharge into the River L'Arc.



Detail of Forebay and End of Penstock



Elevation of Penstock Arch over L'Arc River in France

The penstock, which is 10.82 ft. in diameter, is made of 5/16-in. steel plates at its upper end, riveted with 11/16-in. rivets, and at its lower end—at the power house—is made of ¾-in. plates with 1-in. rivets. The part bridging the river is made of 11/16-in. plates with 1-in. rivets. The span is 223 ft. and the rise of the center line of the arc, 19.7 ft. The pipe line has double-riveted longitudinal lap joints and single-riveted circumferential joints, the plates being in interior and exterior rings placed alternately. A footwalk is placed on top of the arc.

There are two curves in the pipe, one above the arc and one below it. The first curve is simply a 19-deg. deflection made by three successive tapering sections; the other has a radius of 65.6 ft. with a subtended angle of 92 deg. 15 min. The pipe is supported on small concrete piers 20 ft. apart.

The penstock was designed and built for the Companie des Produits Chimiques d'Alais et de la Camargue by Établissements Bouchayer & Viallet, of Grenoble, France.

Penstock with Forebay and Arched Span over L'Arc River

Iron-Ore Statistics

The Amount of Iron Ore Mined in the United States in 1912 was 55,150,147 long tons, as compared with 43,876,552 tons in 1911, an increase of 25.69 per cent, according to Ernest F. Burchard, of the U. S. Geological Survey. Five-eighths of the total was mined in Minnesota, the next four states in order being Michigan, Alabama, New York and Wisconsin. In the Lake Superior district the Mesabi range mined 32,604,756 tons; the Menominee range, 4,465,466 tons; the Gogebic range, 3,926,632 tons; the Marquette range, 3,545,012 tons; the Vermilion range, 1,457,273 tons, and the Cuyuna range, 369,739 tons.

Commonwealth Pier 5, Boston

A 400 x 1200-Foot Pier with a Two-Story Steel Shed on Solid Fill and Pile Foundations between Docks 40 Feet Deep

The State of Massachusetts owns considerable undeveloped land on the waterfront of Boston Harbor, which is now under the control of a board of five directors appointed Dec. 6, 1911. Boston Harbor is from about 200 to 500 miles nearer Liverpool than any other important North Atlantic port on this continent. It has a metropolitan district population of 1,500,000, and is one of the greatest wool markets and leather and textile centers in the world. The imports and exports for 1912 aggregated nearly $199,000,000, the imports having doubled within ten years. It is well adapted for a shipping station for raw cotton and Canadian foodstuffs exported into Europe. It is also favorably located as a port of call of trade routes between northern Europe and the Panama Canal. It has a deep-water entrance to an excellent sheltered harbor with good anchorage ample for a great number of ships.

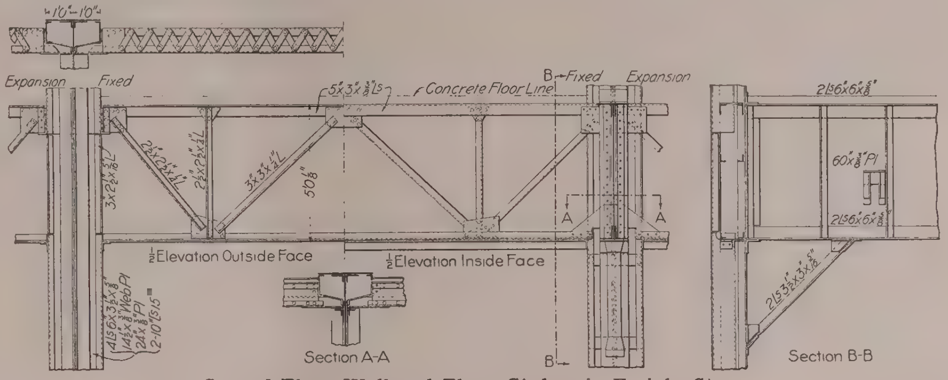
The harbor is not sufficiently developed, and in order to promote the construction of adequate facilities a bond issue of $9,000,000 has been authorized for improvements by the directors of the port. During the year 1912 plans have been made and some work has been commenced in dredging to deepen the channels, and to build piers and sea walls, and plans and surveys have been made for a junction railroad around the city to connect the Northern railroad with the South Boston flats, for tunnels under the harbor between East Boston and South Boston connecting with the various railroad systems, and for a large drydock to be located on South Boston flats.

The Commonwealth flats in South Boston, fronting on the 35-ft. channel and adjacent to the south terminal station, the piers and the freight yard of the New York, New Haven & Hartford Railroad Company are available for the construction of very important improvements, for which the directors have appropriated $2,500,000 to be used in the reconstruction of the 400 x 1200-ft. Commonwealth Pier 5 and pier shed with freight and passenger facilities, railroad tracks and highway connection.

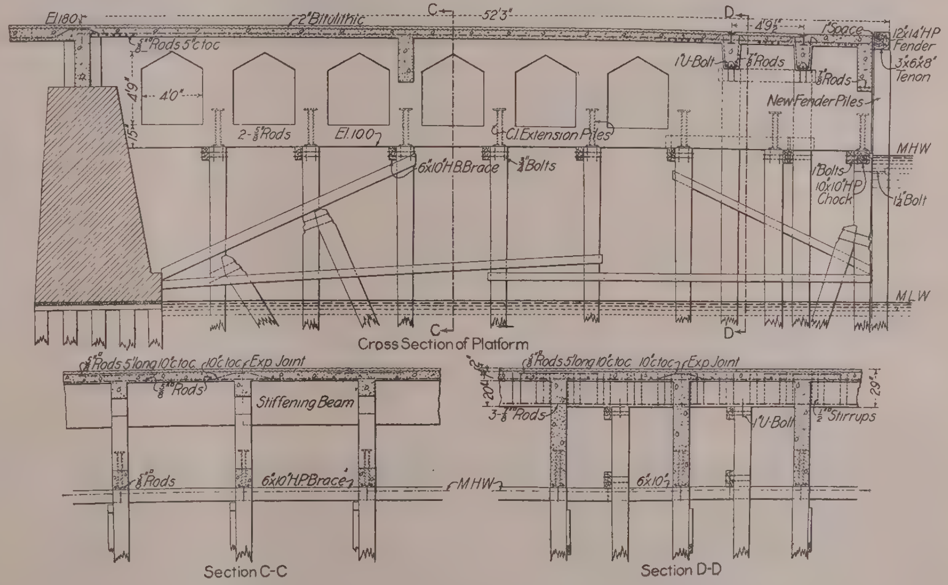
CHARACTER AND AMOUNT OF WORK

The existing pier 5 on the site of Commonwealth Pier was of solid earth 300 ft. wide and 1150 ft. long, inclosed on the two sides and outer end by an oak pile and timber platform 50 ft. wide. All of the timber above the piles has been replaced by reinforced-concrete beams and floorslabs. Pile and concrete foundations and concrete sea walls, retaining walls and curtain walls have been built to support the sheds, and construction is far advanced on the 400 x 200-ft. two-story steel superstructure, with concrete first and second floors and an extensive system of railroad tracks, street paving, sewers, drains, water and electric mains carried below the surface.

The principal quantities involved in the construction of this pier include about 330,000 cu. yd. of dredging, 300,000 lin. ft. of wooden piles, 28,000 yd. of plain and reinforced concrete, 10,000 tons of structural steel, 6200 sq. yd. of street paving, 1800 lin. ft. of sewer pipe of all diameters, 3000 ft. of surface drains, 6800 lin. ft. of water mains and pipes and 500 lin. ft. of electric conduits laid below the surface of the ground, and more than 5000 ft. of standard-gage track laid with 100-lb. rails.



Second Floor Wall and Floor Girders in Freight Shed

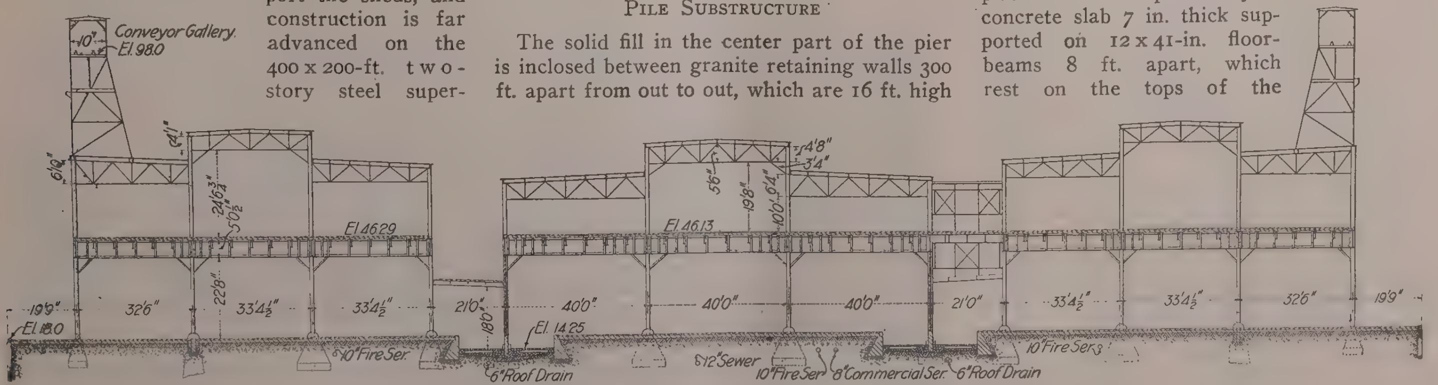


New Concrete Face Wall and Floor Supported on Pile Bents

PILE SUBSTRUCTURE

The solid fill in the center part of the pier is inclosed between granite retaining walls 300 ft. apart from out to out, which are 16 ft. high above mean low tide and are supported on foundation piles protected by riprap and cut-off at mean low tide. These walls supported the inner edge of the inclosing platform, 50 ft. wide, carried on eight rows of oak piles, arranged in transverse bents 8 ft. apart. All decayed or injured piles were replaced and new intermediate two-pile bents driven adjacent to the waterfront to give additional support for the railroad tracks. Clusters of nine piles each were also driven 20 ft. apart to support the piers for a single line of columns on each side of the pier. All piles driven in water under the platform are of oak from 50 to 70 ft. long and 14 in. in diameter 2 ft. from the butt, and are driven to an average penetration of 15 ft. in the original clay bottom. All of the existing woodwork above the pile tops was removed and replaced by reinforced-concrete construction.

About 2700 lin. ft. of the original timber platform was replaced by a concrete slab 7 in. thick supported on 12 x 41-in. floorbeams 8 ft. apart, which rest on the tops of the

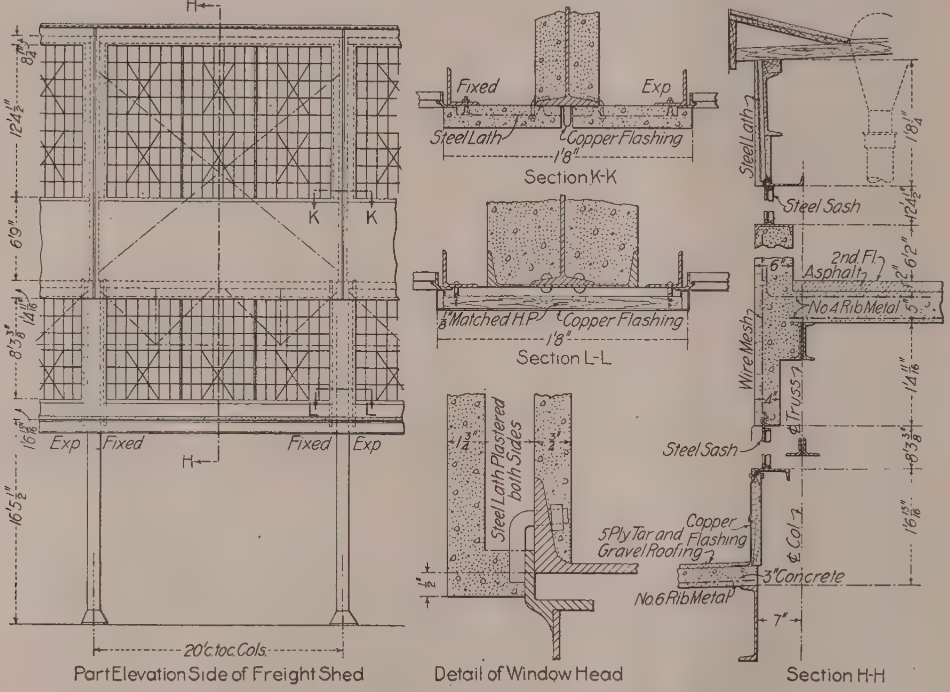


General Transverse Sectional Elevation of Steel Triple Shed Construction on Solid Fill wooden piles and are secured to them by 1-in. iron U-bolt dowels. The inner ends of the floorbeams rest on the granite retaining walls and are framed into header beams connecting the pedestals for the columns in the steel shed. The outer ends are connected by similar header beams protected by a wooden fender. Intermediately the floorbeams are connected by pairs of reinforced-concrete stringers under the railroad track and by parallel longitudinal stiffener beams about midway between the track and the retaining wall. Tongue-and-groove transverse expansion joints are provided about 40 ft. apart in the platform and in all of the longitudinal beams and girders.

Erecting Steel Shed from River End with Boom Traveler

Special Construction Replacing First Platform

Where about 600 lin. ft. of the platform on the east side of the pier had been burned all of the existing woodwork was removed to a level 10 ft. above mean low water, new piles were driven as required, and all piles were capped, at right angles to the pier, by transverse reinforced-concrete beams 12 in. thick and 7½ ft. high up to the bottom of the floorslabs, thus forming practically curtain walls perforated with openings about 4 ft. wide between the piles. These walls were stiffened at the outer and inner ends and at one intermediate point by 12 x 36-in. longitudinal beams and by track stringers similar to those already described.



Structural Details of Steel Frame Exterior Wall for Freight Shed

Short cast-iron columns or pedestals 30 in. high were seated on the tops of the piles, anchored to them, and built solid into the transverse walls or beams, in order to support the platform and upper portions of the beams if the lower portions of the latter should become deteriorated by action of sea water and frost, so as to require repairs at some future time.

Pier Sheds

The steel superstructure consists of three full-length, three-aisle sheds separated by surface railroad tracks, with roofs connecting the adjacent sheds and forming a continuous shelter across the full width of the three sheds. The center shed is 120 ft. wide and will be occupied in the upper story by the passenger department of the Hamburg-American steamship line. One of the side sheds will also be occupied by the steamship company and the remainder of the pier will be available for rental to others. The two side sheds, each about 99 ft. wide, are intended to be used, at first, exclusively for freight service, and will be equipped with electric winches for handling all freight. They will be served by two lines of standard-gage steam-car tracks depressed about 3 ft. below the first-floor level on each side of the center shed and by one line of tracks on each side of the pier outside of the outer sheds. All of the sheds will have throughout a second floor proportioned for a live load of 500 lb. per square foot, with a clearance of 22 ft. 8 in. above the first floor. The second floor in the center shed will be connected with the second floor of each side shed by six covered bridges 20 ft. wide. Both of the side sheds will have structural-steel towers supporting a gallery in which a conveyor will be installed to deliver grain from the grain elevator which is to be built near this pier. Each of the sheds has windows in all of its walls and in the clerestory of the center aisle.

The steel superstructure has transverse column bents 20 ft. apart longitudinally, which carry heavy kneebraced transverse plate girders for the second floor and light riveted roof trusses.

The columns are connected by transverse second-floor plate girders 5 ft. deep, field-riveted to them through hitch angles, and by light riveted longitudinal wall trusses 5 ft. deep. The upper ends are connected by similar longitudinal trusses and by the roof trusses. Longitudinal bracing is provided in the end panels and in every alternate panel in the roof and between the upper portions of the wall columns.

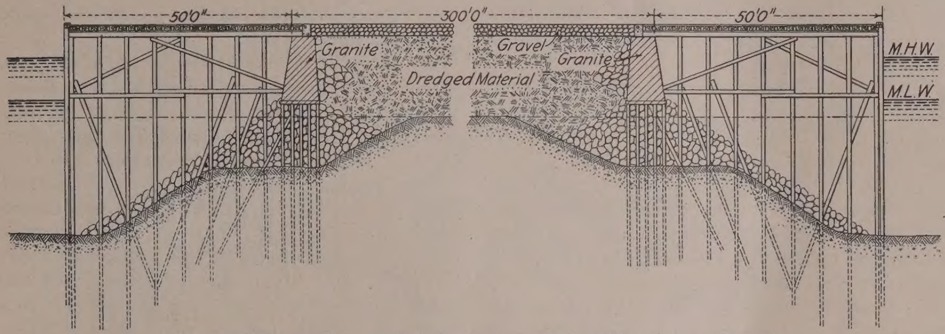
The wall columns are of special construction, having a rectangular cross-section made up of an I-shape center member with a solid web plate and two pairs of flange angles, connected by bent plates to a channel on each side, with

Erection Traveler and Reinforced-Concrete Floor-Slab Construction

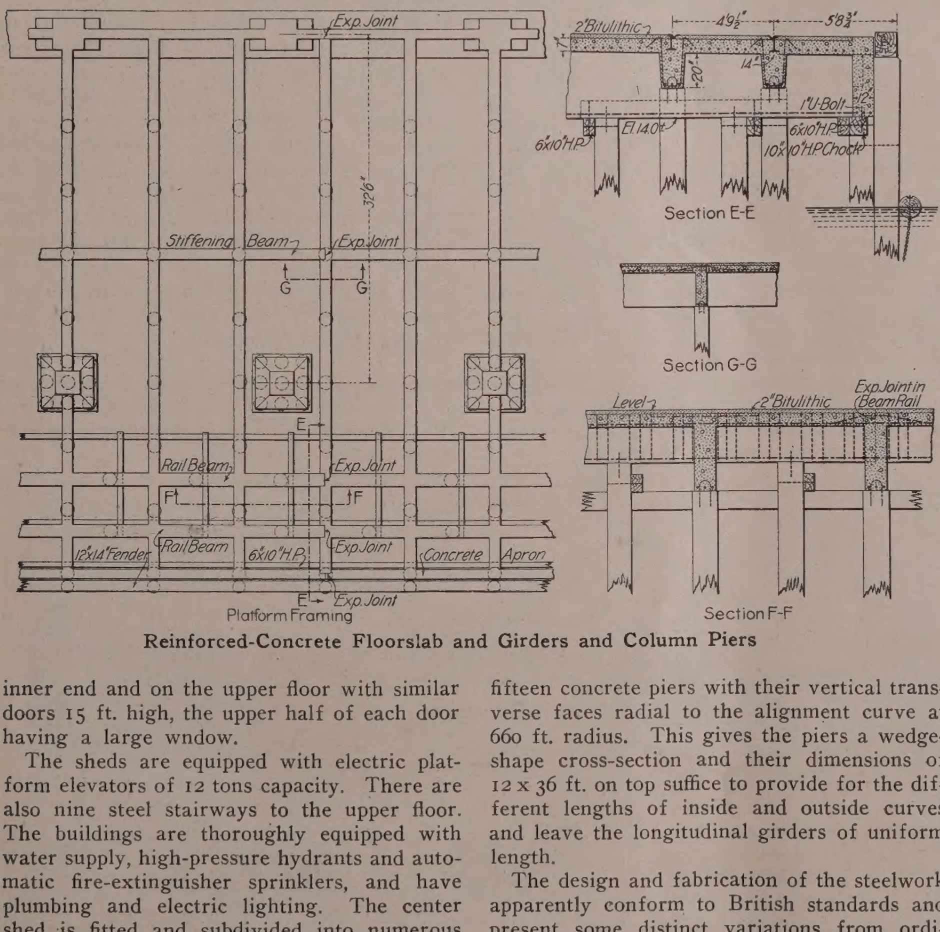
its flanges turned inward to form pockets for the counterweights of the doors.

The first floor has a 10-in. foundation of 1:3:6 Portland cement concrete laid on the solid fill and surfaced with 2 in. of bituminous coating. The second floor is a slab of 1:2:4 reinforced concrete 5 in. thick with bitulithic macadam in the freight sheds and is supported on steel beams spaced about 5½ ft. apart. The roof is of 2-in. tongue-and-groove hard-pine planks covered with five-ply felt asphalt and slag. All gutters and upper parts of conductors are of 16-oz. copper; the lower parts of the conductors are of cast iron.

The walls of this shed along both sides of the pier, except for one bay at the outer end and seven bays at the inner end, are closed on the lower floors with Ogden double-leaf doors 18 ft. wide and 22 ft. high, except for five bays at the outer and seven bays at the inner end and on the upper floor with similar doors 15 ft. high, the upper half of each door having a large wndow.



Transverse Section of Original Commonwealth Pier at Boston



Reinforced-Concrete Floorslab and Girders and Column Piers

The sheds are equipped with electric platform elevators of 12 tons capacity. There are also nine steel stairways to the upper floor. The buildings are thoroughly equipped with water supply, high-pressure hydrants and automatic fire-extinguisher sprinklers, and have plumbing and electric lighting. The center shed is fitted and subdivided into numerous rooms suitable for the first and second class passengers and immigrants and for the United States Customs and Inspection Departments and for various offices, restaurants, toilet rooms, etc.

The design and execution of the work are under the direction of Mr. Frank W. Hogdon, chief engineer; Mr. J. R. Worcester, structural engineer, and Mr. John R. Ferguson, resident engineer. H. P. Converse & Co., of Boston, are the general contractors. The Phoenix Iron Company was the contractor for the fabrication of the structural steelwork, which was erected by Daniel Marr & Son. The John T. Scully Foundation Co. was the contractor for the pile driving.

High Steel Viaduct in New Zealand

The Hapuawhenua single-track viaduct of the North Island Main Trunk Railway of New Zealand is about 970 ft. long and 150 ft. in maximum height from the bottom of foundations. It comprises seventeen 36-ft. plate-girder spans and five 64-ft. deck-track truss spans supported on four steel towers and fifteen concrete piers with their vertical transverse faces radial to the alignment curve at 660 ft. radius. This gives the piers a wedge-shape cross-section and their dimensions of 12 x 36 ft. on top suffice to provide for the different lengths of inside and outside curves and leave the longitudinal girders of uniform length.

The design and fabrication of the steelwork apparently conform to British standards and present some distinct variations from ordinary American practice. The tower columns are pairs of I-beams latticed, with their webs parallel to the alignment. They are braced in 30-ft. stories with horizontal longitudinal and transverse struts and with pin-connected tension diagonals in all of the faces of the tower, as well as in the horizontal planes at each story. The gusset plates to which the main diagonals are connected project beyond both flanges of the horizontal struts, and their edges are deeply notched between the flange angles of the struts; the corners are neatly rounded to give a sort of sawtooth effect, the advantage of which is not stated.

Where the horizontal diagonal rods intersect great pains are taken to make one member with two pieces connected by a shackle at the center through which the opposite diagonal has clearance to pass. As these rods are more than 50 ft. long and only 1⅜ in. in diameter, any vital objection to springing them less than 1 in. to clear at intersections may not be apparent to the American bridge engineer.

The extended bases of the columns are stiffened by vertical tieplates projecting beyond the flanges, with nicely rounded notches cut in their edges, and holes through the faces correspond well with the gusset plates noted in the foregoing. The ends of these plates are bent double and riveted back on the inner sides of the I-beam flanges, thus making in cross-section loops or pockets through which the vertical anchor bolts pass, with their nuts bearing on the upper edges of the plates.

The ends of the truss spans are supported on the top flanges of the longitudinal tower girders, which are made shallower at the end to receive them, the bottom flanges being horizontal and the top flanges inclined at the ends, thus reversing the usual arrangement for drop end girders.

The floorbeams are 20-in., 95 lb. I-beams 12 ft. long and 8 ft. apart, provided with corbel brackets to receive the wooden stringers, one line of which is made 12 x 12 in. and the other 12 x 16¼ in. to provide positively for the superelevation of the outer rail in the curve.

The towers were erected by a wooden ginpole 30 ft. long, which was at first set in a hollow in the concrete pier surface chipped out expressly to receive it. After the first story of the tower was erected the ginpole was hoisted to the top of it by a light wire attached to the top of the permanent column and led through a sheave at the foot of the ginpole, over another sheave at the top of the column and thence to the hoisting engine.

The great irregularity of the surface made the erection difficult, and the tower girders were hoisted inside the towers. The 64-ft. trusses were assembled on the ground between towers and hoisted in an inclined position to clear the tower. Frequent stops were necessary to avoid obstruction, and it was therefore considered safer to hoist them with hand power, which required a maximum of two and a half hours to hoist a 9½-ton truss, rather than to use steam power that was available there.

The work was described by Mr. R. W. Holmes, resident engineer, in a paper published recently in the excerpt minutes of the proceedings of the Institution of Engineers.

A Dredge Boat Improvement for advancing the dredge in the line of operation has been invented by Mr. Alfred Watkins and applied to a suction dredge now removing about 12,000,000 tons of earth for the rectification of the channel of the Loire, France, as described in a recent issue of "Engineering." The boat is fitted with a pivot spud and a rotor spud, the latter passing through a vertical sleeve in a horizontal eccentric plate about 7½ ft. in diameter. The plate is revolved by a worm gear to swing the spud in and out of the line of advance of the boat, so that alternately raising and lowering this spud and the pivot spud enables the dredge cutter to be swung through any required arc parallel to the preceding swing.

Determining Proportions of Concrete Mixtures after Hardening

By H. Burchartz, Royal Testing Laboratory, Berlin-Lichterfelde

A test of cured and hardened mortar or concrete is often desirable in cases where damage has occurred or weakness become evident after the concrete has set, as, for instance, if the concrete is not well formed and remains brittle, if the surface of the mortar shows cracks or exfoliations, if a finished floor gives too early evidence of wear, or if parts of buildings collapse.

In such cases one can determine by testing the material used whether the unsatisfactory setting process of the mortar or concrete is due to too poor a mixture or to other causes.

The question next arises whether positive tests can be made and definite, reliable results obtained as to the exact ratio of cement to aggregate that was used in the mixture.

The ratio in parts by weight can always be determined in cases where the compound contains one cementitious material only—that is, either cement, as is generally the case, or lime, but not if these two or other binding materials are used in the same mixture, and if the aggregate does not contain an appreciable quantity of ingredients soluble in acid, such as carbonate of lime, oxide of iron, soluble silica, china clay, etc., or if not too large a quantity of loam or clay products is contained therein.

Under these favorable conditions the test can be safely made by chemical analysis, treating the dried and crushed materials with dilute muriatic acid. A fault of little importance is that the aggregate usually contains portions of ingredients soluble in acid. Therefore the mixture will be found somewhat too rich and the final analysis will favor the concrete producer.

Proportions by Volume

In practice, however, the materials in question in a concrete mixture are commonly proportioned by volumes. It is, therefore, imperative, especially in practice, that the ratios by weight should be transformed into ratios by volume. For this purpose the weight of a known volume of the materials in question has to be ascertained. If this weight is known, or may afterward be determined, then such calculation is easy and reliable. It is necessary that the weight of the cement which was used for such mixtures be obtainable, as it is not possible to regain the cement in its original state out of the hardened concrete. The aggregate, however, can be regained and tested as to its relative weight and volume, assuming that it is not soluble in acid. One must, however, take into consideration that the degree of humidity under which the aggregate was used is unknown, but forms an important item as to the true result. (See "Testing of Cured Cement Mortar and Concrete, and Lime Mortar, as to Their Mechanical Composition," by Burchartz. "Mitteilungen aus dem Kgl. Materialprüfungsamt." Berlin-Lichterfelde, 1906.)

The Royal Testing Laboratory at Berlin-Lichterfelde proceeds as follows in calculating the ratio of the mixture in parts by volume from those in parts by weight:

In the case of cement mortar or concrete the weight of Portland cement, according to the standard specifications, is 1400 kg. for 1 cu. m., or 1.4 kg. for 1 liter. For the aggregate recovered by technical analysis the ratio of volume to weight is found by taking the average weight of one liter of the material (sand, gravel, broken stone, etc.), moistened by the addition of water equal to 4 per cent of the quantity. For instance, if the proportions of a concrete mixture as to parts by weight are obtained by analysis, as 22 of cement and 72 of gravel, equal to 1:3.3, and assuming that the weight of gravel is 1.60 kg. per liter, then the calculation of the ratio as to parts by volume gives (22/1.40):(72/1.60), or 1.5:4.5 or 1:3.

The question now arises whether or not the ratio obtained by the above method is sufficiently correct—a question of the greatest importance in settling controversy in the building trade and which is gaining more importance every day by the constantly increasing use of concrete and reinforced concrete. (See "Fulfilling of Specifications for the Ratio of Mixture," by Kleinlogel. "Tonindustriezeitung," 1912. No. 25, pages 347-348).

Laboratory Methods

In the laboratory mentioned above an attempt was made to solve this question by analyzing some mixtures of which the composition was known. For this purpose out of one cement and various aggregates several different concrete mixtures were made, using materials of known weights. From these mixtures cubes of 10 cm. length were formed and tamped. The ratios of the mixture, the aggregates used, the weight of the constituents and the per cent of water added are shown in the accompanying table. The test pieces were left uncovered and were sprinkled once daily from the second to the seventh day. Several specimens of mixture 3 were hardened under water.

At the end of twenty-eight days the test pieces were distributed among several chemists for the purpose of determining the proportions. This was done without letting them know the ratio or the purpose of the tests.

The analysis was made by the method above described, except with mixture 6, the aggregate of which contained a considerable amount of carbonate of lime (limestone débris). It was rather impure, besides, and the usual method was not applicable. In this case the chemist analyzed the soluble silica in the concrete in order to ascertain the amount of cement from the analysis of silica. The proportion of silica was thus found to be 22 per cent; that is, standard Portland cement. The results of the tests are shown in the table.

A comparison of the values in column 19 with those in column 2 shows the close accordance of the proportions determined by the test with those really employed in making the concrete. These are especially close if one compares the result of standard-sand mortars with the ratio of mixture for dry sand. In fact, dry sand was used in preparing the standard-sand mixtures, contrary to the custom in practice, and only the results thus arrived at were considered.

Results of Tests to Determine the Proportions of Hardened Concrete

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
					Weight of Materials				Composition Found by Analysis, Percentage by Weight					Properties of the Aggregate				
									Cement		Aggregate							
Mixture No.	Proportions Used. by Volume	Kind of Aggregate	Weight of Cement, Kg. per Liter	*a*Weight of Aggregate, Kg. per Liter, per Cent Water	Cement, Kg.	Aggregate, Kg.	Water, Kg.; Water Addition in per Cent	Method of Storing Specimens	Dry, per Cent	Free from Water and Carb. Acid, per Cent	Sand and Gravel, per Cent	Loamy Particles, per Cent	Ratio of Cement (Free from Water and Carb. Acid) to Aggregate	W_1, *c*Kg.	W_2, *c*Kg.	$\frac{W_1+W_2}{2}$ *c*Kg.	Percentage of Loamy Particles	*d*Calculated Proportions of Mixture, by Volume
1	1:2.5	Stand'd sand	1.330	1.460	1.330	3.650	0.787 (8.0%)	In air	30.6	24.0	70.0	...	1:2.1	1.325 (1.420)	1.678 (1.708)	1.502 (1.565)	...	1:2.8 (Dry 1:2:
2	1:5	Stand'd sand	1.330	1.460	1.330	7.300	0.526 (6.1%)	In air	18.5	14.5	81.5	...	1:5.6	1.325 (1.420)	1.678 (1.708)	1.502 (1.565)	...	1:5.4 (Dry 1.5
3	1:4	River gravel	1.330	1.470 (1.5%)	1.330	5.880	0.751 (6.5%)	In air	20.0	16.6	79.6	0.4	1:5.8	1.539	1.968	1.754	0.5	1:4.0
4	1:4	River gravel	1.330	1.470 (1.5%)	1.330	5.880	0.751 (6.5%)	Under water	20.6	17.6	78.6	0.4	1:4.5	1.551	1.957	1.744	1.0	1:3.8
5	1:8	River gravel	1.330	1.470 (1.5%)	1.330	11.700	0.425 (4.7%)	In air	11.7	9.7	86.8	1.5	1:9.1	1.537	1.930	1.738	1.5	1:7.7
6	1:5	*b*Ditch gravel	1.330	1.540 (4.8%)	1.330	7.700	0.268 (7.4%)	In air	3.84 per cent sol. silica corresponding to 17.5 per cent cement		....	...	1:4.5	On account of material partly soluble in muriatic acid, test could not be undertaken with accuracy				....

(*a*) The unit weight was determined from a 10-liter sample; the standard sand being dry and the remainder of the aggregate in its natural state.
(*b*) The gravel was dirty and full of limestone debris.
(*c*) Figures in parentheses refer to dry material.
(*d*) Calculated from column 14, based upon weight of 1.4 kg per liter, or 86.7 lb. per cubic foot, for cement, and the values in column 17 for the aggregate.

The results of the tests prove that the method may be considered reliable for the ascertainment of the proportions of hardened mortar and concrete. It is doubtful, however, whether reliable results can be obtained if the proportions are ascertained upon the basis of the content of soluble silica in mixtures the aggregates of which contain loamy or impure products, for the results indicate a mixture richer than actually used.

In case of emergency, however, if one is satisfied with an approximation of the real proportions, such methods of determining the mechanical composition may not be prohibitive.

In practice it is not of great importance whether the ratio of mixture proves to be one-half of one unit of volume more or less, especially as on the job an absolutely correct mixture is rarely ever obtained.

Launching a Submerged Sewer Outfall at Ocean Grove

By Marshall R. Pugh, of Pugh & Hubbard, Civil Engineers, Philadelphia

A sewer outfall extending about a quarter of a mile into the Atlantic Ocean was recently put in place at Ocean Grove, N. J., to discharge the effluent from the clarification tanks of a sewer district in Neptune township. The system consists of approximately 10 miles of terra-cotta pipe sewer. The outfall sewer at the beach is 15 in. in diameter. The portion of the pipe in the ocean is of 12-in. standard galvanized wrought-iron pipe manufactured by the Reading Iron Works, with screwed joints and galvanized couplings.

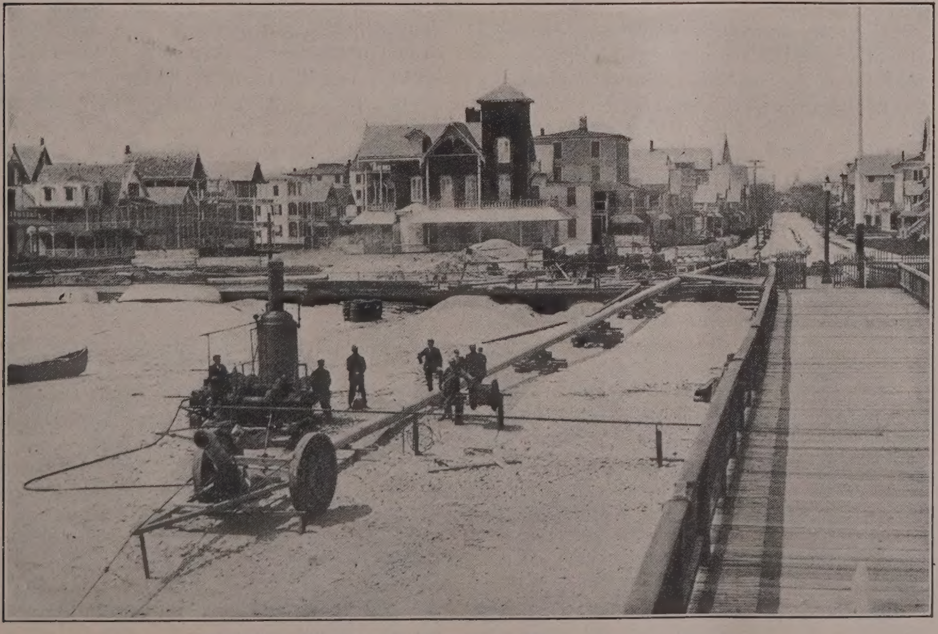
The outlet extends alongside a fishing pier at Embury Avenue; accordingly, the full length of pipe to reach out to sea was screwed together along Embury Avenue. Since the pier came directly opposite the prolongation of the street it was necessary to deflect the pipe at Ocean Avenue. The surface of Embury Avenue being hard gravel, the pipe was placed on small wooden trucks, on the portion laid along the street, while across the grass plot, boardwalk and beach it was necessary to have stationary rollers, blocked up where necessary to the proper grade. To anchor the outer end of the pipe, and also to raise it above the floor of the ocean so that it would be in no danger of choking with sand, this outer end was attached to a cast-iron plate with two cradles and was bent upward at an angle of 45 deg., as shown in the illustration. This outlet anchor weighed approximately 2600 lb. To prevent the water entering while it was being run out to sea the end of the pipe at the anchor was capped with a wooden cap, like a cork in a bottle. This cap was closely but not tightly fitted, and was heavily lubricated with thick white lead at the joint so as to prevent any water entering around it.

Since standard 12-in. wrought-iron pipe floats when filled with air, and a floating pipe might be damaged by the swell of the ocean, a 3-in. "ballast" pipe was laid inside of it for the whole length, and this 3-in. pipe was filled with water, so as to partially sink the larger pipe. Somewhat over a quarter of a mile from the shore were placed five ship anchors, two of these being 500-lb. anchors, the other three being somewhat lighter. When these were firmly embedded a sheave was attached to them, through which was passed a ⅝-in. steel cable. One end of this cable was secured to the cast-iron bedplate of the outlet anchor and pipe, while the other end was attached to the drum of a hoisting engine, and to prevent the outgoing and incoming lines of cable fouling each other, the incoming line was floated by means of five oil casks attached to it at intervals.

Truck for Outlet

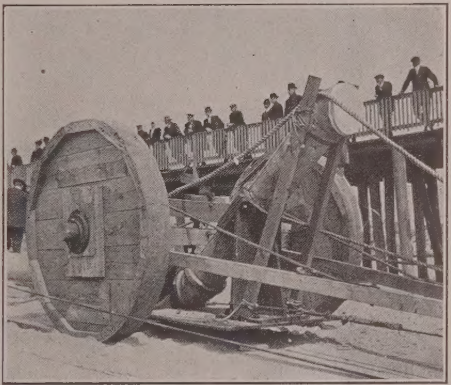
The illustration shows the truck used to enable the heavy outlet anchor plate to be pulled out to sea. It consisted of two 6-ft. wheels made of two thicknesses of 2-in. plank, with a further reinforcement of 2-in. plank on each side at the outer edge by way of a tire, thus making an 8-in. face for each wheel. A hook attached to the axle caught a ring on the anchor plate, raising it about a foot from the beach, and a shaft, through the end of which the steel cable passed, prevented the axle from turning over and dropping the heavy cast-iron anchor plate.

When everything was in readiness a somewhat tedious wait of eleven days took place, for continued east winds and storms effectually prevented any attempt to put the sewer pipe out. At last, Tuesday, April 22, an ideal day permitted the attempt. A light wind was blowing from the west, with a sea smooth and free from swells. When everything was in readiness the shaft on the drum of the hoisting engine broke, but fortunately it was a double-drum hoist, so the cable was attached to the other drum and the tension put upon the cable at 10.15 a. m. To relieve the strain on this cable a rope from the gipsy on the hoist was taken back toward Ocean Avenue and attached to the pipe, so as to assist in pulling. As the point at which this rope was attached came opposite the engine, it was necessary to stop, detach it, take it back and get a new hitch, when operations were started once more. These delays caused it to take two hours and fifteen minutes to put the outlet in place, but the actual time the pipe was in motion was thirty-nine and one-half minutes. As more and more of the pipe left the land it became continuously easier to move it, so that whereas at the start a 21-ft. length of pipe required one minute to move its own length, at the end it only required thirteen seconds to go the same distance.


Hoisting Engine Hauling Long Pipe Line into Ocean

Removing Outlet Plug

When the shore end of the pipe was pulled out somewhat beyond high water mark a bushing was screwed into it having a 2-in. pipe connection to a steam pump. Water was pumped in, which settled the outlet pipe, and also compressed the air in it. When this compression reached a sufficient amount to more than neutralize the pressure of the 33 ft. of water overlaying the outlet anchor the plug blew out like a cork from a popgun, admitting the water and sinking the pipe. An air pocket having formed near the shore end, a ¼-in. hole was drilled in the pipe, allowing this air to escape, the hole being closed by screwing a bolt into it. The pipe now lay along the bottom of the ocean, the end at the beach being about 3 ft. below high-water mark and the outer end about 33 ft. below. The 3-in. ballast pipe was withdrawn and a temporary cap placed at the shore end until the connection with the sewer could be made.


Wheel Truck for Outfall

When the tension on the cable was released the weight of the anchor plate caused the shaft on the truck to tilt up, allowing the hook to disengage the anchor, whereupon the truck floated to the surface and was brought ashore.

Messrs. Pugh & Hubbard, of Philadelphia, were the engineers, and the Monmouth Contracting Company, of Red Bank, N. J., was the contractor for the disposal works and outfall sewer. The subcontractors for the ocean outlet were Mathews Brothers, also of Red Bank, to whom is due great credit for the successful execution of the work.

Metered-Water Service in Chicago is proposed by the water department. An ordinance to meter every one of the 17,000 service pipes is under way.

Suspended Grillage Foundation of Thirteen-Story Building

The excavation in Church Street, New York, for Section 1 of the Lexington Avenue subway is through fine wet sand which becomes unstable and threatens the undermining of adjacent tall and heavy buildings. These buildings have therefore been underpinned by sectional steel lattice girders, assembled in position at the site and supported on piles consisting of pipes sunk below subgrade and filled with concrete before the general excavation was completed. The details of design and operation have been developed in the execution of the work by Frederick L. Cranford, Inc., contractor for this section of the subway, which is being built under the direction of the Public Service Commission, of which Mr. Alfred Craven is chief engineer and Mr. Robert Ridgway engineer of subway construction.

The thirteen-story building at the corner of Cedar and Church Streets has, adjacent to the subway, four wall columns with estimated loads of about 1300 tons each on grillage footings in the sand about 15 ft. below the surface of the street and 10 ft. above the subgrade of the subway. The cellar floor and earth were excavated to expose the tops of the grillage beams on both sides of the columns, and on them were assembled, on each side of the row of columns and close to them, a pair of continuous lattice girders 30 in. deep, made of pairs of 6 x 6-in. flange angles and 4 x ¾-in. flat web members, all field-bolted together to make a 42-ft. line of four girders extending across the full front of the building.

Close to each side of each column over the south grillage there were set on the top flanges of the lattice girders a pair of 20-in. I-beams, 14-ft. long, transverse to the building line. Long welded links of 1-in. square wrought iron were set vertically in the spaces between the I-beams and girders and steel keys were passed through their upper ends to take bearing on transverse pieces set on the top flanges of the 20-in. I-beams. Similar keys through the lower ends of the links engaged the bottom surfaces of the top flanges of the grillage beams so that wedges driven under the upper keys developed a lifting stress tending to suspend the grillage beams from the lattice girders. Over the north grillage the 20-in. I-beams were omitted and the links were turned 90 deg. and engaged the top flanges of the lattice girders directly, because the grillage beams are at right angles to those in the south grillage and thus facilitated this arrangement.

On both sides of the lattice girders 5 x 5-ft. pits were excavated and sheeted down to water level about 3 ft. below the bottom flanges of the girders and in each pit five 14-in. sectional riveted steel pipes were jacked below subgrade. The interiors were excavated and concreted. They were capped and received cast-iron columns wedged up to bearing against the bottom flanges of the lattice girders, thus transferring the column loads imposed on the latter to the pile foundation at a point below any disturbance from the subway construction. All of the beams and girders will be inclosed by forms and concreted, thus providing a solid extended foundation for the entire front of the building, supplemented by the piles which carry the load to a safe footing.

The Production of Rolled Iron and Steel in the United States during the year 1912 amounted to 24,656,841 long tons. This includes all kinds of finished products and semi-finished products rolled for export.

Letters to the Editor

False Economy in Engineering Construction

Dear Sir: The editorial "False Economy in Engineering Construction" in the issue of Aug. 23, page 199, is well taken and especially that part touching on the non-revision of plans after construction. An incident of this kind was impressed on the writer, at that time in charge of a gang of laborers excavating for retaining-wall footings on grade separation work in Chicago. At one point a telephone conduit was uncovered, running diagonally across the excavation and about 2 ft. above the bottom of the footing grade. A street lay adjacent and parallel to the railway property line.

The engineer in charge of the railway field work consulted his plans, which showed that the conduit was an old one, formerly connected with the depot before the latter was removed, so he gave orders to tear out the conduit. This conduit, however, proved to be a live one, containing approximately fifty wires, and within a few minutes after the wires were out a number of telephone men were on the job.

When the conduit was put in, the construction forces, instead of following the plan, had cut diagonally across to a manhole. The plan showed the conduit line straight down the middle of the street, with a right-angle turn to the manhole. The result of not bringing the plans up to date was a serious interruption of service on about fifty phones. This incident shows the necessity for bringing plans up to date after a job has been completed, especially when the plans relate to underground work.

Chicago. K. L. Van Auken, C.E.

Clauses in Contracts

Dear Sir: I read with a great deal of interest the recent comments in your paper with regard to clauses in specifications which are unjust to contractors and I am very much disinclined to agree with you that the usual contracts are fair to both parties. As an instance, I have copied here part of a specification recently issued by one of the Government bureaus:

"The contractor will excavate on the reservation where the representative of the ——— shall direct a well which will be connected to the pumps in the cellars. The excavation will be made circular and of sufficient depth to furnish a constant daily supply of water throughout the year equal to at least 500 gallons. If rock is encountered before the specified amount of water is obtained, the contractor will be allowed 75 cents for each cubic yard excavated to obtain the amount of water above specified."

You can see from the above that the contractor might possibly have to go down several hundred feet before obtaining the required amount of water and that the job might cost him $100 or it might cost him $2,000, the Government, however, not paying him one cent extra if he happened to guess wrong as to what depth water would be found at on the Government property. You will also notice that the price of 75 cents per cubic yard of rock is ridiculously low for excavation in a well.

The clause as above quoted is an example of the many clauses of a similar character which architects and engineers continually write into their specifications and which endeavor to place upon the contractor responsibility which really belongs to the architect, the engineer or the client.

New York. Charles F. Dingman.

Corrosion of Metals

Dear Sir: In connection with articles on the problem of corrosion of metals, published in your issue of Aug. 23, certain results obtained recently in our laboratories may be of interest to your readers. The results outlined below were obtained in an investigation of corrosion in a hydroelectric plant. In considering the problem it was assumed that analyses of samples of the rust itself might throw some light on the problem, at least to the extent of indicating if acids present in the water would be found in the rust. Five samples, therefore, were taken and analyzed. It was assumed that these would contain occluded clay matter or silt in addition to products of corrosion, and the samples were treated with dilute hydrochloric acid, the insoluble portions consisting of silt or clay matter being analyzed separately.

The samples were found to contain:

Description of sample	From turbine shutters	From steel screen	From C. I. pipe	From connecting rod	From wrought iron pipe
Insoluble in Hydrochloric Acid					
Silica (SiO_2)	2.80	10.16	4.84	15.96	2.90
Alumina and iron oxide (R_2O_3)	1.44	4.60	2.44	5.76	1.52
Lime (CaO)	None	None	None	None	None
Magnesia (MgO)	None	None	None	None	None
Sulphuric anhydride (SO_3)	None	None	None	None	None
Soluble in Hydrochloric Acid					
Silica (SiO_2)	0.72	0.40	0.44	0.24	0.76
Ferric oxide (Fe_2O_3)	67.92	62.24	65.34	55.20	77.84
Alumina (Al_2O_3)	None	None	None	None	None
Lime (CaO)	None	None	None	None	None
Magnesia (MgO)	None	None	None	None	None
Sulphuric anhydride SO_3)	1.22	2.16	1.83	1.36	2.36
Carbon dioxide (CO_2)	None	None	None	None	None
Water (H_2O)	26.28	21.28	24.72	22.24	14.88

It will be noted from these analyses that these rust samples consist largely of hydrous oxide of iron, together with occluded matter and small quantities of sulphate of iron. The water used at this plant contained on the average of from 1 to 2 grains of sulphuric anhydride per U. S. gallon.

The corrosion at this plant was very extensive and appeared to become much more rapid when a spongy coating of rust had formed.

So far as we know, these are the first published analyses of rust, as examination of considerable literature bearing on the subject failed to disclose any.

Henry S. Spackman Engineering Co.,
E. L. Conwell, Secretary.
Philadelphia.

The Lister Dam in Germany was officially dedicated on July 5. It is one of the structures built at the instigation of the "Ruhrtalsperren-verein" (see Engineering Record of July 19, 1913, page 72) and will be of importance for the water users on the Lister, Lippe and Lenne rivers. Its maximum storage capacity is 660,000,000 cu. ft. It collects the runoff from a drainage area of 25.8 sq. miles. The dam itself is made of cyclopean masonry and has a capacity of 140,000 cu. yd. The total cost of the reservoir, including the cleaning of its basin, is $1,010,000.